BUSITEMA UNIVERSITY

Pursuing Excellence

FACULTY OF AGRICULTURE AND ANIMAL SCIENCES

DEPARTMENT OF CROP PRODUCTION AND MANAGEMENT

PROPOSED CURRICULUM FOR THE MASTER OF SCIENCE IN PLANT BREEDING PROGRAM (MPB)

MARCH 1, 2022

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PREAMBLE

Plant breeding is an all-encompassing and multi-disciplinary science and art of improving crop plants. It involves the application of many scientific disciplines such as genetics, agronomy, statistics/biometrics, plant pathology, agricultural entomology, molecular biology, scientific communication and other relevant disciplines. The multi-disciplinary nature makes it suitable for individuals who aspire to develop or improve crop varieties for yield, quality, resistance to plant parasites, drought and low soil fertility adaptation and maintaining and evaluating plant genetic resources. It is also suitable for those who wish to develop varieties with special use to support local plant breeding and seed science systems to meet stakeholders' needs and respond to indigenous demands. Products of these efforts positively impact on the production of food, feed and fibre. The training also prepares one to be a hardworking, dedicated and self-reliant individual with the ability to work with diverse groups of people. In addition, the programme cultivates written and verbal communication skills, which enables one to be self-motivated and fit in all walks of life.

OVERVIEW OF BUSITEMA UNIVERSITY

1.1 BUSITEMA UNIVERSITY

Busitema University was established as a public university under the Universities and other Tertiary Institutions Act, 2001 (statutory Instrument No. 22, 2007) with a mandate to provide quality tertiary education through teaching, research and outreach. The university was established under a multi-campus model, with its main administrative campus located at the Busitema campus along the Jinja-Tororo highway. Currently, the university has six operational campuses, namely; Busitema campus (Engineering sciences), Nagongera campus (Science and Education), Namasagali campus (Natural Resources and Environmental Sciences), Mbale campus (Health Sciences), Pallisa campus (Management Sciences) and Arapai campus (Agricultural and Animal Sciences). The University is guided by a vision of being "*A center of academic and professional excellence in science, technology and innovation*". Basing on its motto, *"Pursuing excellence*," the University alumni excel in their careers and positively contribute to society's development. The University's mission is "*To provide high standard training, engage in quality research and outreach for socio-economic transformation and sustainable development*. The University Core Values are; Excellence, Relevance, Innovativeness, Professionalism, Ethics and Integrity, Equity, Internationalization and Respect for Diversity.

1.2 FACULTY OF AGRICULTURE AND ANIMAL SCIENCES

The Faculty of Agriculture and Animal Sciences currently has six academic programmes, namely; Certificate in General Agriculture (CGA), Diploma in Animal Production and Management (DAP), Diploma in Crop Production and Management (DCP), BSc. Animal Production and Management (APM), BSc. Agribusiness (BAB) and Bsc. Agriculture (BSA). The certificate and diploma programmes run for two years, APM and BAB are three-year programmes while BSA is a four-year programme. The faculty is designing post graduate programmes in agriculture and extension, agribusiness and animal sciences to contribute towards the national objectives of increasing household income, job creation, ensuring food security and sustainable development.

1.3 DEPARTMENT OF CROP PRODUCTION AND MANAGEMENT

The department of Crop Production and Management hosts the DCP and BSA programmes. Its mission is to develop human resource capacity at different levels and undertake research, outreach and advocacy in the areas of crop production and management to support the national goals of economic development and poverty reduction. The department is developing postgraduate programmes to meet the needs of those wishing to advance in the academic career beyond their bachelor's degrees.

1.4 JUSTIFICATION

Currently, the global population that stands at 7.7 billion is expected to reach nine billion by 2040 and 9.9 billion by 2060 at the current global population growth rate of 1.15% (UN, 2019). The ever-increasing world population growth rate of man and other animals comes with many socioeconomic challenges: food and feed shortage. For example, globally, the prevalence of undernourishment and hunger has remained at about 11% while the total number of undernourished and hungry people has slowly increased over the years, with over 820 million people suffering hunger, corresponding to one in nine people globally. The situation is alarming in Africa and worst in the East African region with 19.9 and 30.8% of the population living with hunger respectively (FAO, 2019). To tackle this challenge, the United Nations member countries developed the sustainable development goal (SDG) one and two of no poverty and zero hunger, respectively by 2030. Uganda developed the vision 2040 and the National Development Plan III to tackle the same challenges. It then calls for a concerted effort to develop technologies that will increase food and food production in tandem with population growth. This creates a direct need for human resources with the capacity to develop technologies that lead to increased food and food productivity. Plant breeding then comes in handy in providing answers to developing human capacity that can develop technologies that lead to increased food productivity and availability and increase household income for poverty reduction. The course helps to find new ways to expedite the production of new high yielding crop varieties that are better adapted to dynamic low, input production environments. The integrative and holistic nature of plant breeding offers a successful career path for many with different expertise to develop to a higher level that may lead to pursuing further studies. The diverse nature of the course also improves one's competitiveness in the job market where one may be relevant in

working environments such as the academics, breeder companies, high level managers and policy making.

2.0 PROGRAMME OBJECTIVES AND LEARNING OUTCOMES

2.1 GENERAL OBJECTIVE

The overall objective is to have an all-round graduate who will be a change agent in the field of cultivar development to solve challenges of low productivity and acceptability of improved crop varieties.

2.2 SPECIFIC OBJECTIVES

The specific objectives of this postgraduate training in plant breeding are to produce graduates with knowledge, skills and competencies capable of:

i. Understanding and designing teaching, extension and decision-making activities in plant breeding programs.
ii. Understanding, designing and managing plant breeding programs for specific crop species under particular conditions to meet the food and market demands
iii. Integrating conventional and modern techniques in plant breeding that increase efficacy in the selection processes and hasten the development of new varieties that meet desired food and market demands
iv. Managing and carrying out rigorous research on plant breeding problems.
v. Understanding and applying the principles and techniques of modern plant breeding, particularly genomics, biotechnology and genetic modification, among others

2.3 PROGRAMME LEARNING OUTCOMES

On successful completion of this program, a student will be able to:

i. Independently plan and design plant breeding experiments and programs for crop improvement for various biotic and abiotic constraints.
ii. Implement and apply various plant breeding techniques and develop/produce new crop seed varieties
iii. Collect and convert data from heritable traits into information using various statistical tools

iv. Appreciate the importance, conservation and regulation of plant genetic resources
v. Use the descriptors in various crops for the selection of superior genotypes and manage breeding populations to maximize progress from the selection.
vi. Design and conduct a crop improvement research project aimed at solving crop production problems within a dynamic agricultural environment
vii. Teach and effectively conduct extension programs in plant breeding

3.0 DETAILS ABOUT THE PROGRAMME

3.1 TITLE OF THE PROGRAMME

The programme shall be called a: **Master of Science in PLANT BREEDING (MSc. PLANT BREEDING)**

3.2 BACKGROUND TO THE MSc. PLANT BREEDING PROGRAMME

The MSc Plant Breeding programme is a hands-on practical course aimed at training students in the field of breeding for crop improvement and management. In this programme, scientific knowledge and skills are provided where the student is able to design a market-oriented plant breeding project aimed at developing and improving plant genotypes to meet the desired demands of end users. This is achieved by the students adopting participatory approaches to improving crop genotypes to adapt to various constraints and environments, leading to increased productivity and acceptability of the developed or improved genotypes.

Through the use of conventional and modern practical skills and tools the students are prepared to handle simple to complex crop improvement tasks to enhance their competitiveness for national and international employment opportunities, especially in the academia, research and seed sectors. As a result, the programme prepares a student to meet employers' needs in addition to being job creators.

3.3 MINIMUM ADMISSION REQUIREMENTS

The programme targets, for admission, persons with at least a first degree (Hons) in general agriculture or equivalent Bachelor of Science related programmes such as Horticulture, Animal Science, Botany, Plant Biotechnology, Forestry, Natural Resources Management from a recognized and chartered university/institution as a minimum requirement. In case the degree was awarded without classification, evidence will be required that performance was equivalent to an

honours degree. Applicants whose previous experience is inadequate may be required to take some selected undergraduate agricultural modules where necessary.

3.4 PLACE OF STUDY

The lectures and tutorials shall normally be taken from the premises of the Arapai Campus of Busitema University, while research projects shall be undertaken at the institutions approved by the Senate of Busitema University or any relevant body entrusted by Busitema University.

3.5 IMPLEMENTATION OF THE CURRICULUM

The programme shall be implemented as lectures, tutorials/seminars, practical work, group assignments and independent studies.

3.6 PROGRAMME AND COURSE DURATION

The programme shall be offered as full time, and it will take a minimum of two academic years (four semesters) and a maximum of four academic years (eight semesters). The programme shall be run on a semester system where each academic year shall have two semesters. A semester shall comprise of 17 weeks where 15 weeks shall be used for lectures and continuous assessment, while the two weeks shall be for university exams for each course.

The programme will be offered in course format as course work, university examinations and thesis. Each candidate will be required to take and pass all course(s), each taking 45 hours covered in a semester. Each student will undertake a plant breeding research project leading to an examinable thesis. The choice of the thesis research topic shall be made in consultation with the department and the academic supervisor(s). In addition, there will be a recess term of ten (10) weeks after the first academic year, during which students will develop research proposals and prepare for their research projects.

Students will be attached to institutions conducting active plant breeding programmes during the recess term. Such institutions will include research centres and seed companies

3.7 COURSE CODING

The programme content is implemented in course form where each covers a particular aspect of training. Each course has a code and credit units attached to indicate its weight. The coding shall start with MPB to indicate Master in Plant Breeding, followed by digit 6 or 7 to indicate first and second year of study, respectively. This shall be followed by two-place digit 1 to signify course

number. Course codes shall thus be MPB6101…. and MPB6201…… for the first year and MPB7101… and MPB7201 for the second year.

3.8 COURSE LOAD

The programme shall take a period of four consecutive semesters (two consecutive academic years), of which the first three will be for undertaking course work and the last for research. Each student shall take a minimum of FOURTEEN (14) courses, twelve (12) of which shall be core courses and any two elective courses of one's choice. In the second year, students will do courses and research in a breeding project, leading to writing a master's thesis. Depending on the student's bachelor's degree background, undergraduate courses may be done for students to fully acquire the knowledge needed to complete the Master of Science degree in Plant Breeding.

3.9 PROGRAMME CONTENT AND COURSES

The programme content is divided into courses, each of which is designed to cover a particular aspect of the training. Each course has a code, and the credit units attached to the course indicate its weight.

(a). A credit unit shall be equivalent to a series of contact hours (CH) or one contact hour (3 OR 4) per week per semester. These may be converted into nominal hours where a credit unit is equivalent to ten (10) nominal hours.

(b). A contact hour shall be equivalent to one hour of lecture or two hours of tutorial or practical/fieldwork.

(c). No course shall carry less than two credit units.

3.10 STUDENT ASSESSMENT AND GRADING

3.11 STUDENT ASSESSMENT

The Master's degree guidelines and quality assurance policies and practices of Busitema University shall apply and be adhered to. The assessment will be done on a continuous basis, followed by university examinations. Continuous assessment will comprise of tests, quizzes, assignments, field study trips, graduate seminars conducted by Busitema University lecturers or visiting lecturers with unique specialities. The grading will be as follows; the continuous assessment will constitute 40% (10 tests, 10 graduate seminars, 10 assignments and 10 practicals

and field study tours) and 60% for written university examination. The continuous assessment grading may change as need arises but students are required to attend at least 75% of all scheduled lectures and practicals. The overall pass mark will be 60%.

The MSc. Plant Breeding (MPB) thesis shall conform to the standard guidelines and regulations of the University Higher Degrees Committee. In addition, the student has to:

1) submit a research proposal which shall be peer reviewed and approved,

2) conduct research on a peer reviewed and approved topic,

3) hand in three hard copies and a soft copy of the thesis for examination, and

4) submit a revised thesis within six months after notification for a student whose thesis does not meet the minimum standards for a pass. No viva voce is needed, but a student is required to present his/her research findings during seminars.

3.12 STUDENT GRADING

Each course unit shall be graded out of a maximum of one hundred percent (100%) marks and assigned appropriate letter grades and grade points as shown in the table below.

Table1: Letter grades and grade points

Marks (%)	**Letter Grade**	**Grade points**	**Remarks**
80-100	A	5.0	Excellent
75-79.9	B+	4.5	Very good
70-74.9	B	4.0	Good
65-69.9	C	3.5	Satisfactory
60-64.9	D	3.0	Pass
0-59	E	2.0	Fail

3.13 CALCULATING THE CUMULATIVE GRADE POINT AVERAGE (CGPA)

The CGPA shall be calculated using the following formula below:

$$CGPA = \frac{\sum_{i=1}^{n} (GP_i * CU_i)}{\sum_{i=1}^{n} CU_i}$$

Where GP_i is the Grade Point Score in a course *i*; CU_i is the number of Credit Units of courses done by the student *i*; and n is the number of courses taken in that semester or recess term. CGPA is calculated using a formula similar to the above, but *n* is the number of courses taken from the beginning of the program up to the time when the CGPA is being calculated less the courses that do not count towards the CGPA especially undergraduate courses that a student has taken.

3.14 DEGREE CLASSIFICATION

The degree of Masters of Science in Plant Breeding shall be awarded to a student who fulfils all the programme requirements and the MSc. Plant Breeding degree shall not be classified.

3.15 SPECIAL EXAMINATIONS

A student who is unable to do the final university examination during the assessment weeks due to unforeseen circumstances may be allowed to take a special examination before being awarded the degree. All students with valid reasons during the time of continuous assessments are required to submit documentation to the Faculty Dean's office in support of their case and will be given the assignments.

3.16 SUPPLEMENTARY EXAMINATIONS

In the event that a student scores less than 60% in the final mark (final university examinations and continuous assessment) in one or more courses, s/he will be required to sit for a supplementary examination of the failed course(s). To pass the said course(s), the student must score at least 60% in the said examinations. If a supplementary examination is done, the final assessment mark will have the abbreviation (S) put beside such a course on the transcript to signify that the subject was passed after a supplementary.

3.17 RETAKING COURSE(S)

This applies to a continuing student who;

i) Fails the final assessment of the course (continuous assessment and university exams combined)
ii) Fails the final assessment of the course and takes a supplementary and fails it too
iii) Fails to do coursework during the semester

iv) Absconds from doing the final assessment

v) Wants to improve on his/her pass grades

However, while retaking a course(s) a student will:

a) Attend all the prescribed lectures and continuous assessments during the course(s);

b) Satisfy all the requirements for the course work in the course(s); and

c) Sit for the university examinations of the course(s).

A student shall not be allowed to accumulate more than three (3) retakes at a time. Students are required to register for retakes first before registering for new courses offered in that semester. The retakes should fit into the approved normal semester load to avoid timetable clashes. When a student re-takes the course(s), the score mark s/he has obtained in that course shall be used to compute his or her cumulative grade point average (CGPA). Whenever course(s) are retaken, the academic transcript shall accordingly indicate **(R)** against the course(s). This will not apply to the student who is retaking to improve his/her pass grades.

3.18 PROGRESSION

Progression of a student is classified as either normal or probationary progress. Normal progress applies to a student who has passed all the required courses that make up the complete semester load and obtained at least a cumulative grade point average (CGPA) of 2.0. A student on probation progress is one who has failed at least one course and has a CGPA of less than two (CGPA < 2.0). That student shall be allowed to progress to the next semester/academic year but shall still retake the course(s) until s/he obtains a pass of 60%.

3.19 REPEATING AN ACADEMIC YEAR

A student may be permitted to repeat an academic year at the discretion of the Faculty Board and Senate if faced with medical challenges or s/he fails more than three (3) courses in that academic year.

3.20 DISCONTINUATION

A student shall be discontinued from the Masters programme if s/he fails to obtain CGPA of 3.0 after doing the retake(s) for more than two (2) times in course(s) or absconds from studies or stays for more than two consecutive years without a valid reason.

3.21 CREDIT TRANSFER AND EXEMPTIONS

A student may be exempted from taking some course(s) and be allowed to transfer credits of the same course(s) up to a maximum of one third (⅓) of the taught units, provided that these are from institutions recognized by the University authorities and National Council for Higher Education (NCHE). A student seeking transfer of credit units shall formally apply to the Board of Postgraduate Studies through the Dean, Faculty of Agriculture, justifying the request.

3.22 THESIS EXAMINATION

i) Each student shall make a seminar presentation of the research proposal.

ii) Each candidate shall submit for examination a thesis APPROVED by the academic supervisors at the end of the final semester. The thesis shall be examined in accordance to the approved regulations of Busitema University.

iii) A candidate who fails in the thesis examination may, on the recommendation of the Faculty Board of examiners, be allowed to resubmit the thesis within six months up to a maximum of two times.

iv) A candidate who fails after the second submission or fails to complete the course in the prescribed period shall, on the recommendation of the Faculty Board and approval by the Senate, be discontinued.

4.0 PROGRAMME STRUCTURE

The programme structure is as indicated in Table 2 below.

Table 2: Programme structure of the MSc. Plant Breeding of Busitema University

S/N	COURSE CODE	COUSE NAME	LH	TH	PH	CH	CU	COMMENT
	YEAR ONE: SEMESTER ONE (17 WEEKS)							
1	MPB 7101	Principles of genetics and plant breeding	30	15	15	45	3	Core course
2	MPB 7102	Population and quantitative genetics	30	15	15	45	3	Core course
3	MPB 7103	Modern methods and techniques used in crop improvement	30	15	15	45	3	Core course
4	MPB 7104	Advanced biometrics-1: experimental and mating designs	30	15	15	45	3	Core course
5	MPB 7105	Research process and research ethics	30	15	15	45	3	Core course
6	MPB 7106	Breeding for quality traits	30	15	15	45	3	Core course

	YEAR ONE: SEMESTER TWO (17 WEEKS)							
7	MPB 7201	Plant genetic resources conservation and intellectual property & breeders' rights	30	15	15	45	3	Core course
8	MPB 7202	Designing a sustainable and successful plant breeding programme	30	15	15	45	3	Core course
9	MPB 7203	Seed technology and variety release	30	15	15	45	3	Core course
10	MPB 7204	Applied agricultural extension	30	15	15	45	3	Core course
11	MPB 7205	Scientific communication, writing skills and proposal development	30	15	15	45	3	Core course
		RECESS TERM (10 WEEKS)						
	YEAR TWO: SEMESTER ONE (17 WEEKS)							
13	MPB 8101	Advanced biometrics-2: multivariate and multiple regression	30	15	15	45	3	Core course
14	MPB 8102	Crop physiology	30	15	15	45	3	Elective
15	MPB 8103	Agricultural entomology and plant parasitic nematodes	30	15	15	45	3	Elective
	YEAR TWO: SEMESTER TWO (17 WEEKS)							
16	MPB 8201	Plant pathology	30	15	15	45	3	Elective
17	MPB 8202	Soil fertility improvement and management	30	15	15	45	3	Elective
18	MPB 8203	Msc. Plant Breeding Thesis					18	Core course

4.1 DETAILED PROGRAMME STRUCTURE

4.1.1 YEAR ONE: SEMESTER ONE (17 WEEKS)

4.1.2 COURSE NAME: PRINCIPLES OF GENETICS AND PLANT BREEDING

COURSE CODE: MPB 7101

CREDIT UNITS: 3

COURSE OVERVIEW

The course will provide students with a broad overview of genetics and modern concepts of heredity by providing the basic principles, concepts and theories as applied in plant breeding. A brief review of Mendelian genetics will be covered in addition to the breeding methods of inbreeding, outcrossing and clonally propagated crops.

COURSE OBJECTIVES

i) To have basic knowledge about Mendelian genetics and its implication in plant breeding.

ii) To know about the various population improvement programmes.

iii) To learn breeding procedures in self- and cross-pollinated crops and vegetatively propagated crops.

iv) To understand the genetic basis underlying the various crop breeding methods.

LEARNING OUTCOMES

Students shall be able to:

i) explain the basic principles of genetic material transmission from one generation to another

ii) predict the outcomes of genetic crosses when parental genotypes or phenotypes are known

iii) enhance ability to understand the fundamental principles of genetics and describe the experiments used to establish them

iv) apply the principles of inheritance as formulated by Mendel

v) analyze genetic data using statistical procedures

vi) identify characteristics of self- and cross-pollinated plants and their implications in crop improvement

vii) determine breeding methodology appropriate for plants with different mating systems

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1.	Introduction	Definition of Plant Breeding; History of Plant Breeding; Objectives of Plant Breeding; Achievement of Plant Breeding; Role of plant breeding in feeding the future generation. Prospects of a green revolution in Africa. Rules of Inheritance: Milestones in genetics, levels of genetics (classical, molecular and population)	3
2	Mendelian inheritance	DNA – structure, function, replication and repair. Genetic code. Cell structure and division, Linkage, its detection and estimation. Epistasis. Extra chromosomal inheritance. Gene-enzyme relationship. Replication,	5

		Transcription and Translation. Chromosome number, structure, function and replication. Mendel's Laws of Inheritance. Allelic interactions; co-dominance and incomplete dominance; overdominance; pleiotropism; lethals and sub-lethals; penetrance and expressivity. Position effect Variegation. Epistasis: Non-allelic interactions and modification of Mendelian ratios. Verification of Mendel's laws of inheritance.	
3	Breeding methods in self-pollinated crops	Plant Introductions as a method of plant breeding: Single Seed Descent; Bulk Population; Multiline Varieties; Back Cross methods; pedigree; Hybrid breeding. Highlight the Procedure, Purpose and Achievement, Merits and Demerits similarities and differences where possible of each method	3
4	Genetic basis of breeding self pollinated crops	pure line theory and its genetic basis; genetic consequences of hybridization (segregation and recombination of genes); composition of populations derived from hybrids; role of genotype and environment in continuous variation; heritability; genetic advance under selection.	3
5	Breeding methods in cross pollinated crops	Introduction and Acclimatization, Line Breeding and Mass Selection Recurrent Selection, synthetics and composite varieties, Hybridization (inbreeding depression effects and degree, heterosis and heritability estimation). Highlight the Procedure, Purpose and Achievement, Merits and Demerits similarities and differences where possible of each method.	4
6	Genetic basis of breeding cross pollinated crops	Genetic basis of self-incompatibility and male sterility and its importance in hybrid development; genetic basis of inbreeding depression and heterosis; exploitation and fixation of heterosis; genetic basic of population improvement. Genetic and molecular basis of heterosis: Dominance and over-dominance theories, inbreeding and heterosis; possible role of epistasis in heterosis; estimation of genetic diversity and the expression of heterosis.	3
7	Breeding methods in	Procedures for developing clones and selection, definition and Characteristics of Clones, Genetic Variation within Clones Merits and Demerits of Clonal	4

	asexually propagated crops	Selection. Problems in Breeding of Asexually Propagated Crops. Achievements in clonal breeding.	
8	Mating systems for components of variation and generating breeding lines	Self-fertilization, full sib mating, half sib mating, back crossing; inbreeding and backcrossing; random mating, assortative and disassortative matings, sister line crosses, convergent crosses, complex crosses, diallel mating, generation mean analysis, North Carolina designs, top cross designs, line x tester designs, poly-crosses.	5
9	Mutations and polyploidy breeding	Mutation breeding, distant hybridization and polyploid breeding, mutant variety data (MVD)-IAEA	3
10	Tutorial	Flower morphology and anatomy of cross pollinated and self-pollinated plants, emasculation, Field trips to Research institutions where there are breeding programs.	15
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

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Tomlekova, N.B., M.I. Kozgar and M.R. Wani. 2014. Mutagenesis: exploring genetic diversity of crops. ISBN: 978-90-8686-244-3.

4.1.3 COURSE NAME: POPULATION AND QUANTITATIVE GENETICS

COURSE CODE: MPB 7102

CREDIT UNITS: 3

COURSE OVERVIEW

The course focuses on establishing the genetic architecture of quantitative genetics and estimating gene frequencies in populations. The course also highlights the types of gene action in population breeding and importance of genotype by environment interaction in crop improvement programmes.

COURSE OBJECTIVES

i) To learn the various technologies and ways to improve crop varieties and genetic stocks.

ii) To transform the genetic make-up of plants for better quality and commercial yielding

iii) To produce improved cultivars and novel germplasms

iv) To gain experience in analysing and interpreting data from genetics experiments

LEARNING OUTCOMES

At the end of the course learners should be able to:

i) implement the various technologies and ways to improve crop varieties and genetic stocks;

ii) transform the genetic make-up of plants for better quality and yield; develop improved cultivars through their research projects;

iii) appreciate that physical variation observed in the members of a population;

iv) apply the Hardy-Weinberg Law in analyzing population genetics for gene frequency, sex linkage, equilibrium, and heterozygote frequency;

v)have a thorough understanding of the principles underlying population genetics.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Introduction	Definition, scope and goals of breeding for quantitative traits,	2
2	Genetic architecture of quantitative traits	Conventional analyses to detect gene actions - Partitioning of phenotypic/genotypic variance – Construction of saturated linkage maps, concept of framework map development; QTL mapping- Strategies for QTL mapping - desired populations, statistical methods. Population Genetics and Birth of Neo-Darwinism	2
3	Estimation of gene frequencies in populations	Hardy -Weinberg law. Factors affecting HWE gene frequencies: migration, mutation, selection; random drift and inbreeding, equilibrium in small populations; population differentiation and pooling of sub-populations (Wahlund effect), F-statistics (F_{ST}, F_{IS} and F_{IT}).	2
4	Inheritance of quantitative traits	Monogenic inheritance, Oligogenic inheritance, Polygenic inheritance, Maternal effects	2
5	Combining ability and gene effects	Combining ability (General and specific combining ability); additive dominance and epistatic gene effects; line × tester analysis; diallel analysis (Hayman and Griffing's approaches): generation-means analysis, scaling tests (six, five and three parameters models); North Carolina Designs, triple test cross, top cross, poly cross	2
6	Quantitative traits	Features of quantitative traits (Population mean, average effect, breeding value, dominance deviation, interaction deviation). Components of Phenotypic Variance. Genetic architecture of quantitative variance, Genotypic Values: Additivity, dominance and epistasis, genetic covariance	3

		(Offspring and one parent, offspring and mid-parent, half sibs, full sibs). Correlated characters, GxE effects and maternal effects. Heritability estimation (ANOVA and Regression).	
7	Quantitative Genetics	Traits controlled by two loci, three loci and multi-loci; Heritability, measurement of variability. Inbreeding and Heterosis: Measurement of inbreeding -inbreeding coefficient, Panmictic index	2
8	Molecular Basis for Inheritance of Quantitative traits (QTL genetics)	Requisites for QTL mapping: Mapping populations {F2, backcross (BC), doubled haploid (DH) and recombinant inbred line (RIL) populations}, molecular linkage maps, data for QTL mapping (marker data and phenotype data). Statistics for QTL mapping: Likelihood function, maximum likelihood estimates, likelihood ratio tests; the LOD score approach; expectation maximization (EM) algorithm (compare with least square method)	4
9	Bayesian approach for QTL mapping	Introduction, Bayes' theorem, simple and conditional probabilities, advantages of Bayesian analysis	2
10	Interval QTL mapping	Maximum likelihood and regression approaches and their comparison for QTL analysis, expectation maximization algorithm, joint segregation of QTL and marker genotypes, simple interval mapping (SIM) and composite interval mapping (CIM), multiple trait mapping (multiple trait simple interval mapping and multiple trait composite interval mapping), advantages of CIM over SMA and SIM	4
11	Linkage disequilibrium (LD)	Linkage: Concepts, recombination, gene mapping, fine structure mapping. Meaning of LD. Measures of LD, factors affecting LD, LD and association mapping in plants.	3
12	Limitations for Quantitative Breeding	Limitations for breeding for quantitative traits in common crops are highlighted.	2
13	Genotype-environment interaction and stability analysis	Varietal evaluation in multi-location/multi-year trials; estimation of g × e and stability parameters following the models of Finlay and Wilkinson, Eberhart and Russell, Perkins and Jinks, Freeman and Perkins; AMMI model; GGE biplot.	4

	for selection	Simultaneous selection models: Discriminant function; classical, restricted and general selection indices.	
14	Tutorials	Working out efficiency of selection methods in different populations and interpretation. Biparental mating use of software in analysis and result interpretation Triple Test Cross (TTC) use of software in analysis and result interpretation Advanced biometrical models for combining ability analysis Selection of stable genotypes using stability analysis: Models in stability analysis; Additive Main Effect and Multiplicative Interaction (AMMI) model, Principal Component Analysis model, Shifted multiplicative model. Analysis and selection of genotypes: Methods and steps to select the best model - Selection systems. Biplots and mapping genotypes. Construction of linkage maps and QTL mapping Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies.	11
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

REFERENCES

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Nadarajan, N. 2005. Quantitative genetics and biometrical techniques in plant breeding. Kalyani Publishers.

Thirugnanakumar, S., K. Saravanan, N. Senthilkumar, A. Anadan. Quantitative Genetics and Crop Breeding. ISBN: 9789380235981.

4.1.4 COURSE NAME: MODERN METHODS AND TECHNIQUES USED IN CROP IMPROVEMENT

COURSE CODE: MPB 7103

CREDIT UNITS: 3

COURSE OVERVIEW

The course provides theory, methods and procedures required to apply modern plant breeding techniques and review the applications of biotechnology in plant breeding programs. Students will acquire knowledge on biotechnological applications in crop improvement. Students should also know the biotechnology methods applied to plant breeding. Students should be able to describe the advantages and disadvantages of the different methods covered in the course. They will be exposed to modern techniques such as mutagenesis, polyploidy techniques, genetic mapping, principles and methods of different molecular markers, marker assisted selection and genomics. Ultimately, students should be able to identify the appropriate method and strategy to be applied depending on the species, the breeding goals, the population and the timeframe.

COURSE OBJECTIVES

The course goal is to familiarize students with the application of modern plant breeding techniques information to plant breeding. By the end of the semester students should be able:

i) To discuss the organization of plant genomes and regulation of gene expression

ii) To demonstrate an understanding of the principles of tissue culture, plant transformation and vectors for transformation

iii) To explain how to find candidate genes in a process and evaluate them in terms of their function through marker assisted selection

iv) To discuss the social aspects of plant biotechnology and interpret the laws regulating GMOs and their application

v) To impart knowledge and practical skills to use biotechnological tools in crop improvement.

LEARNING OUTCOMES

At the end of the learning of this unit a student shall;

i) be familiar with the different types of molecular markers mostly used in genetic studies and has experience in the construction and comparison of genetic maps

ii) understand the main applications of molecular markers in genetic studies and breeding programmes

iii) have practical experience in DNA extraction and in the use of markers

iv) have practical experience in the use of computer software for the construction of genetic maps

v) Knowledgeable about social aspects of and regulations governing GMOs

vi) be able to analyse information from plant molecular biology research and recognize its potential applications in crop improvement

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks). The delivery mode will be based on lectures and hands-on activities that apply what is learned.

S/N	Topic	Content	CH
1.	Introduction	Overview of modern techniques used in plant breeding. Definition of common terms	2
2.	DNA manipulation	Techniques of DNA isolation, quantification and analysis; Genotyping; Sequencing techniques; Vector preparation and cloning, Biochemical and Molecular markers: morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs, DARTs etc.), mapping populations (F2s, back crosses, RILs, NILs and DH).	3

3.	Protoplasmic fusion or somatic hybridisation and cybridisation	Definition of somatic hybridisation and cybridisation. Steps involved in somatic hybridisation (fusion of protoplast, selection of hybrid cells and identification of hybrid plants). Application of somatic hybridisation and cybridisation. Advantages and Limitations of somatic hybridisation.	4
4.	Plant tissue culture and Creating Somaclonal variation	Definition of tissue culture. Somatic (asexual) procedures (haploids, protoplasts, cell selection) and their applications. Tissue Culture Applications for the Genetic Improvement of Plants. Application of plant tissue culture in agriculture. Procedure of tissue culture: Callus culture (characteristic features, cytodifferentiation, significancy), suspension cultures (types, growth patterns, significance), cloning; Regeneration; Somatic embryogenesis; somatic hybridization techniques; Meristem, ovary and embryo culture; cryopreservation.	4
5	Application of culture technologies to plant improvement	Micropropagation protocol and application. Anther culture protocol and application. Protoplast culture and somatic hybridization protocols and application. Cryopreservation –procedure and applications. Somaclonal variation-causes, merits and demerits.	2
6	Marker assisted breeding and selection	Definition of markers. Types of molecular markers. Review of basic terminology and concepts of Direct Markers, Linked Markers and Gene/SNP. "Chips. Use of genetic markers in breeding value prediction (defining the models, Selection index approaches, Sequencing information (DNA and RNA). Marker assisted selection (simultaneous selection based on marker and phenotype) and molecular breeding; Genomics and Geno-informatics for crop improvement; Integrating functional genomics information on agronomically/economically important traits in plant breeding; Marker-assisted backcross breeding for rapid introgression, Generation of EDVs. Factors influencing MAS; Heritability of the trait, proportion of genetic variance, linkage disequilibrium between markers and traits and selection methods	6
7	Induced Mutation breeding/mutagenesis	Definition of mutation breeding. Types of mutation breeding (Point Mutation, Deletion mutation, Insertion mutation, Forward mutation,	4

		Back-mutation, Lethal mutation, Frame-shift mutation, Suppressor mutation. Mutants and types of mutation agents and their effects. Reasons for mutation breeding. Advantages and disadvantages of mutation breeding.	
8	Haploidy breeding/Double haploids technique	Definition of haploids. Types of haploids (monoploids, polyhaploids and aneuhaploids). Methods of haploid production (anther culture and chromosome elimination), identification, androgenic and gynogenetic, and parthenogenic haploids, meiotic pairing, utility (hybrid sorting and DH breeding). Reasons for developing haploids. Utilising polyploids in crop improvement. Advantages and disadvantages of utilizing haploids in crop improvement.	4
9	Polyploidy breeding	Definition of polyploids. Types of polyploids (autopolyploid, allopolyploids). Methods of production of polyploids. Cytological and genetic methods for identification of polyploids. Polyploidy genetics (chromosome and chromatid segregation), meiotic pairing (autosyndesis and allosyndesis), diploidizing system (Ph1 locus). Utilising polyploids in crop improvement. Advantages and disadvantages of utilizing polyploids in crop improvement.	4
10	Genetic Engineering	GE tools and techniques. GMOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in countries where GMOs are acceptable, ethical, legal and social issues; Intellectual property rights	4
11	Ideotype breeding	Ideotype concept, ideotypes of selected crops (wheat, rice, maize, cotton, pigeon pea, mung bean and chickpea), super plant types, green revolution (treasures and liabilities)	2
12	Nanotechology	Nanotechnology and its applications in crop improvement programmes.	2
13	Bioinformatics	Bioinformatics & Bioinformatics tools used in crop improvement.	4
	Tutorial		**15**
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done inform of quizzes, paper discussions, tests, assignments, presentations, tutorials and lab activities. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

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Ram, M. 2014. Plant Breeding Methods. PHI Learning Pvt. Ltd. ISBN: 9788120348509.

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4.1.5 COURSE NAME: ADVANCED BIOMETRICS -1: EXPERIMENTAL AND MATING DESIGNS

COURSE CODE: MPB 7104

CREDIT UNITS: 3

COURSE OVERVIEW

The course focuses on helping students decide on appropriate experimental and crossing designs depending on available quantity and quality breeding materials used in studies. Students will be trained in statistical modeling and in the choice of experimental designs to use in scientific investigations.

COURSE OBJECTIVES

i) To create awareness of available experimental and crossing designs and analysis methods.

ii) To enable a student to analyze data for genetic experiments

iii) To identify the most appropriate experimental and crossing designs for specific needs

iv) To enable a student to analyze and extract useful information from trials

v) To enable a student to analyse MET data and make selections based on results

LEARNING OUTCOMES

Students will be able to;

i) design factorial field and green house experiments to evaluate varieties and perform appropriate data analysis using ANOVA

ii) students will be able to identify appropriate mating/crossing designs to conduct genetic analysis

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Introduction	History of Experiments. Overview of experiments. Theory and Literature of experimental and crossing designs	4
2	Principles for designing experiments	Randomisation, Replication, Stratification, Sub-sampling, experimental units and Nested designs and their ANOVA, Validity. Hypotheses, Effects Sizes. Sampling.	4
3	Factorial Experiments	ANOVA for a Two-way Factorial: Contrasts and Comparisons Power Analysis Three-way Factorial.	2
4	Complete experimental designs and Basics of modeling	Completely Randomised design (CRD) its ANOVA and model. Randomised Complete Block Randomised design (RCBD) its ANOVA and model; Split Plot Design; Lattice; Lattice design. Multiple Comparisons (Post-Hoc Comparisons) LSD, Tukey, Dunnett. Introduction to Random, Fixed and Mixed effects Models.	4
5	Incomplete experimental	Why and when to use Incomplete blocks design; Latin Square design; Augmented designs.	4

	designs		
6	Experimental and Mating designs	Comparisons and contrasts	2
7	Mating designs for genetic analysis	Decision making options in development of breeding strategies for improvement of the target traits. Applications of mating designs in plant breeding. Genetic components analysis through North Carolina 1,2,3; Diallel 1,2,3,4; Line x tester, Top cross; generation mean analysis and three-factor mating designs; why and when to use mating designs. Covariance, heritability, combining abilities, genetic parameters, progeny evaluation and parental selection. Genotype X environment interaction analysis methods.	6
8	Application of mating designs in breeding	Assessing gene action using various mating designs basing on available resources such as breeding materials and time. When to use what (decision making process).	4
9	Tutorial	Data collection and analysis using various software such as SAS, GENSTAT, BMS/IBP, CYMMYT and R-Statistic	15
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done inform of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

REFERENCES

Anil K.J., P. Flynn, and A.A. Ross (Eds.). 2008. Handbook of Biometrics. Springer. ISBN: 9780387710402.

Boulgouris, N.V., K.N. Plataniotis and E. Micheli-Tzanakou. 2009. Biometrics: Theory, Methods, and Applications (Vol 9). John Wiley & Sons. ISBN: 0470522348, 9780470522349.

Dean, A., M. Morris, J. Stufken and D. Bingham. Handbook of Design and Analysis of Experiments. CRC Press. ISBN: 13-9781466504349.

Lawson, J. 2015. Design and Analysis of Experiments with R. CRC Press. ISBN-13: 978-1439868133.

Seltman, J.H. 2018. Experimental Design and Analysis.

4.1.6 COURSE NAME: RESEARCH PROCESS AND RESEARCH ETHICS
COURSE CODE: MPB 7105

COURSE OVERVIEW

The research process and ethics is a hands-on course designed to impart skills and ability to students to ethically conduct research in agricultural sciences. The students are examined and practically exposed to the main components of a research framework i.e., proposal development, problem definition, research design, data collection, literature review, ethical issues in research and report writing. The knowledge acquired in this course enables one to explore the ethics of scientific research in crop improvement and write the thesis.

COURSE OBJECTIVES

i) To develop a research orientation among students by exposing them to the basic concepts used in research

ii) To develop understanding of the basic framework of the research process through proposal and thesis writing.

iii) To identify various sources of information for literature review.

iv) To Appreciate the components of scholarly writing and evaluate its quality.

v) To acquire an overview of important issues in applied research ethics, like responsibility for research, ethical vetting, and scientific misconduct.

vi) To understand the purpose and value of ethical decision-making

LEARNING OUTCOMES

i) Students will be challenged to think broadly about the role of scientific research in society as well as learn how to critically assess the ethical consequences of science.

ii) students will be able conduct reproducible scientific research.

iii) Students will develop ability to develop theories, formulate and test hypotheses and methods used in agricultural scientific research.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Introduction to Research	Meaning of Research and importance of scientific research in agriculture, Objectives of Research, General Characteristics of a good scientific Research	4
2	Research Design	Concept and Importance in Research – Features of a good research design – Exploratory Research Design – concept, types and uses, Descriptive Research Designs – concept, types and uses. Experimental Design: Concept of Independent & Dependent variables.	6
3	Research proposal writing	Define research proposal, why research proposal is important, basic sections of the proposal, how to develop a good proposal; contents and importance of a research proposal (summary, introduction, literature review, materials and methods, work/activity plan or time line, budget, references/bibliography, additional documents (appendixes) Problem Identification & Formulation – Research Question – Investigation Question –Measurement Issues – Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance	7
4	Thesis writing/report generation using a particular	Writing front matter: thesis (title/cover page format, developing table of contents, list of tables, list of figures, list of plats, list of appendixes, abstract, Main thesis content: writing a good abstract, summary and a chapter	7

	format	introduction; writing chapter one of the thesis (introduction); writing chapter two (literature review and its importance); writing research chapters (layout: abstract, introduction, materials and methods, results, discussion); writing last thesis chapter (general discussion, conclusions and recommendations); referencing/bibliography and appendices	
5	Use of tools/ techniques for Research	Methods to search required information effectively, Reference Management Software like Zotero/Mendeley/Endnote, Software for paper formatting like LaTeX/MS Office, Software for detection of Plagiarism	5
6	Ethical issues in conducting research	Overview of fundamentals and theories research ethics. Good research practice, research integrity and misconduct in research. Criteria and principles for good research practice and ethical decision making. Meaning of scientific misconduct and fraud. Causes and procedures for establishing misconduct, preventions and sanctions. Ethical vetting of research: Different kinds of vetting of research, procedures and ethical principles guiding research on human beings and animals. The ethics of publication and peer review. Managing ethical issues such as bias, fraud, plagiarism, conflicts of interest, falsification of research results, informed consent, attribution of authorship and adequacy of peer review publication processes.	6
	Tutorials	Make oral presentations on a topic that leads to developing a research proposal	10
	Total		45

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in inform of quizzes, tests, presentations, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

REFERENCES

Antonio Sandu, Ana Frunza, and Elena Unguru. 2019. Ethics in Research Practice and Innovation. IGI Publishers. ISBN13: 9781522563105.

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Shanti Bhushan Mishra and Shashi Alo. Handbook of Research Methodology. Educreation Publishing. ISBN: 978-1-5457-0340-3.

4.1.8 COURSE NAME: BREEDING FOR QUALITY TRAITS

COURSE CODE: MPB 7106

CREDIT UNITS: 3

COURSE OVERVIEW

The course highlights the importance of plant breeding and classification and inheritance of qualitative traits. Students also study the various breeding and screening methods for qualitative traits in addition to noting the limitations face in breeding for the traits.

COURSE OBJECTIVES

i) To learn the various technologies and ways to improve crop varieties and genetic stocks.

ii) To transform the genetic make-up of plants for better quality and commercial yielding

iii) To enable students to understand the basic concepts of genetics qualitative traits and mechanism of heredity

LEARNING OUTCOMES

At the end of the course learners should be able to:

i) implement the various technologies used to improve crop varieties and genetic stocks;

ii) transform the genetic make-up of plants for better quality and yield;

iii) develop improved cultivars through their research projects.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Introduction	Definition, scope and goals of breeding for quality traits, examples of qualitative traits.	3
2	Classification of quality traits	Morphological, Organoleptic (taste), Nutritional, Biological, cooking quality, shelf life	3
3	Inheritance of Qualitative Traits	Monogenic inheritance, Oligogenic inheritance, Polygenic inheritance, Maternal effects	4
4	Screening Methods for Different Quality Traits	Common screening methods for quality traits are identified. Screening and quantifying oils, proteins, micro nutrients (magnesium, Zink, molybdenum….), macro nutrients (iron, phosphorous, calcium), amino acids, aflatoxins, vitamins A, B complex, C, E, K, anti-nutritional factors	6
5	Sources of quality traits	Examples of different sources of quality traits are identified. Such sources may include cultivated crops/varieties, Somaclonal variants, wild relative, stored germplasm, spontaneous or induced mutants, transgenics	3
6	Breeding approaches for quality improvement	Selection from available germplasm, Intra and inter specific hybridization, mutagenesis, Somaclonal variation, ploidy breeding, genetic engineering	3
7	Breeding methods for improving quality traits	Breeding methods for improving quality traits do not differ from those for improving quantitative traits. These include; recurrent selection, mass selection, backcrossing, pedigree selection, single seed descent, mutagenesis	4
8	Qualitative traits of selected crops	Legumes (soybean, cow pea, green gram, pigeon pea), oil (ground nuts, sesame, sunflower), cereals (maize, rice, wheat, sorghum, pearl millet,	6

		finger millet, barley, sugar cane), root crops (coco yams, cassava, sweet potato, potatoes), plantains and cooking banana, coffee, tobacco, common vegetables, forage crops. Quality traits (protein, minerals, Beta-carotene, oil quality, phytate, cooking and processing quality, selflessness, industrial uses,	
9	Limitations for Quality Breeding	Limitations for breeding for quality traits in common crops are highlighted.	4
10	Tutorial	Floral biology in self and cross pollinated species, selfing and crossing techniques. Selection methods for quantitative traits in segregating populations and evaluation of breeding material; Analysis of variance (ANOVA); Estimation of heritability and genetic advance.	15
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

REFERENCES

Brazauskas, G., G. Statkevičiūtė, K. Jonavičienė (Eds.). 2018. Breeding Grasses and Protein Crops in the Era of Genomics. Springer. ISBN: 13-9783319895772.

Hulke, B.S., W.R. Fehr and G.A. Welke. 2004. Agronomic and seed characteristics of soybean with reduced phytate and palmate. Crop Science, 44:2027–2031.

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Saini, P., C. Singh, P. Kumar and R. Francies. 2020. Breeding for nutritional quality improvement in field crops. In: Classical and Molecular Approaches in Plant Breeding. Narendra Publishing House.

Tandzi, L.N., C.S. Mutengwa, L.M.E. Ngonkeu, N. Woïn and V. Gracen. 2017. Breeding for Quality Protein Maize (QPM) Varieties: A Review. Agronomy 7(4): 80.

4.1.7 YEAR ONE: SEMESTER TWO (17 WEEKS)

4.1.8 COURSE NAME: PLANT GENETIC RESOURCES CONSERVATION AND INTELLECTUAL PROPERTY & BREEDERS' RIGHTS

COURSE CODE: MPB 7201

CREDIT UNITS: 3

COURSE OVERVIEW

Plant genetic resources are important for the success of breeding programs and the long-term resiliency of agriculture. It is thus critical to train students in good practices for effective plant genetic conservation and sustainable utilization of genetic diversity in crop improvement.

COURSE OBJECTIVES

i) To exploit the protocols required for the conservation and exploitation of plant genetic resources diversity: collecting missions, *in-situ* and *ex-situ* conservation, multiplication, characterisation and agronomic evaluation, exchanges of material.

ii) To develop a practical understanding of the utilization of genetic resources in crop improvement.

iii) To equip students with essential knowledge in documentation and database management of plant genetic resources.

iv) To equip students with phenotypic and molecular techniques to characterize and evaluate plant genetic resources.

v) To enhance awareness of national and international policy instruments and regimes concerning access to and exchange of plant genetic resources.

vi) To equip students with knowledge about intellectual property rights (IPR) related protection systems, their significance.

vii) To explaining how to derive value from IP and leverage its value in new variety development

LEARNING OUTCOMES

At the end of the lecture, the student is able to:

i) develop a project in plant genetic resource management on model plant;

ii) explain the steps requested for the plant genetic resources management; analyse the influence of plant biology on genetic resources management;

iii) critique *in-situ* and *ex-situ* techniques for plant genetic resources conservation.

iv) identify different types of Intellectual Properties (IPs) and scope of protection

v) be familiar with the processes of Intellectual Property Management (IPM) and various approaches for IPM and conducting IP and IPM auditing and explain how IP can be managed as a strategic resource

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Introduction	Definition of plant genetic resources and IPR. Historical perspectives of PGR conservation; Taxonomical classification of cultivated plants; Gene pool: primary, secondary and tertiary;	2
2	Economic benefits of plant genetic resource conservation	Importance and Utilization of Plant Genetic Resources and indicators of genetic erosion. Importance of biodiversity to national development and food Security. Challenges/threats of conserving plant genetic resources	2
3	International Approaches to	Role of International Organizations in Plant Germplasm Resources. The Role of the Consultative Group on International Agricultural Research. The Role of	4

	World Plant germplasm conservation and use	the International Plant Genetic Resources Institute. The International Convention on Biodiversity, Agenda 21. The Global Plan of action	
4	Germplasm management	Collecting, Preserving, and Cataloguing Plant Genetic Resources. Categories of germ plasm collections.	2
5	Germplasm conservation	In-situ, ex-situ, cryopreservation and on-farm cost and benefits of conservation. Duration of conservation: short-, medium- and long-term conservation strategies for conservation of orthodox seed and vegetatively propagated crops. Places where germplasm is conserved (Seed Banks, Germplasm Banks of Vegetatively Propagated Plants, Tissue Culture Banks, Cryobanks, DNA and Cloned Genes). Database Systems Linked to Plant Genetic Resources.	6
6	The Application of Plant Genetic Variation to Achieve Genetic Gains in Plants	The Basis of Genetic Improvement: Variability, Heritability, and Selection Pressure. Molecular Applications to the Conservation and Use of Plant Genetic Resources	2
7	Methods for genetic diversity analysis	Morphological. Biochemical characterization/evaluation (allozyme), in the pregenomic era. DNA (or molecular) marker analysis of genetic diversity. Statistical genetic diversity data analysis methods (Measuring polymorphism). Multivariate and clustering analysis: Shannon's information index (I). Similarity coefficients (Jaccard coefficient (J), simple-matching index (SM), Sørensen-Dice index or Neil and Li index (SD)). Allele frequency-based approaches. Allelic diversity. Effective population size (Ne). Heterozygosity (H). F-statistics of fixation indices.	6
8	Role of genetic diversity information	Taxonomy, origin and evolution, selecting what to conserve. Role of Indigenous knowledge in plant genetic resources conservation	2

9	Policies instruments for plant genetic conservation	Conservation and Sustainable Use under the International Treaty. The national biodiversity strategy and action plan: priorities and target. Current Status and Prospects of Plant Genetic Resources Conservation and Utilization in Uganda. The state of regional and international collaboration	2
10	Role of FAO/CGIAR system for access to genetic resources	ITPGRFA and global system of PGR; FAO's commission on PGR (CPGR); International code of conduct for PGR collection and transfer; multilateral system for access of PGR.	
11	Advances in plant genetic resources conservation	Case studies in in-situ conservation (wild and cultivated varieties) and ex-situ conservation (annual and perennial plants, orthodox and recalcitrant seeds).	3
12	Intellectual Property Rights (IPRs)	TRIPs and various provisions in Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement; Benefits of securing IPRs. Fundamentals of patents and copyrights. Protection of biodiversity, plant varieties and farmers' rights. National Biodiversity protection initiatives, Licensing of technologies, Material transfer agreements. IPRs in plant breeding: UPOV, plant breeders rights (PBRs); protection of plant varieties and farmers rights act (PPV & FRA) 2001; intellectual property rights-patents, copyrights, trademarks; GATT and TRIPs, patents for higher plants; terminator and traitor techniques (v-GURT and t-GURT); biodiversity act 2002; geographical indications act 1999; amendments to patents act 1970	5
13	Ownership and Access Issues in Plant Germplasm Conservation and Use	Intellectual Property Rights, Patents, and Royalties on Germplasm. Apportionment of Ownership for Germplasm of Complex Origin. Farmers' Rights. Genetically Modified Organisms and Transgenics: Their Potential, and Hindrances to Their Adoption to be used as germplasm sources in crop improvement.	4
14	Tutorials and	Visit to plant genetic resources centre and botanical gardens to study about	5

	study tours	ex-situ and in-situ conservation methods. Description of how to conserve plant genetic resources for crop improvement. Synthesizing the Framework of Strategic Management of Intellectual Property (IP). Analyse different IP management (IPM) approaches and describing how pioneering firms initiate, implement and manage IPM programs,	
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of quizzes, tests, presentations, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

REFERENCES

Brian V. Ford-Lloyd and Michael Jackson. 2010. Plant Genetic Resources: An Introduction to their Conservation and Use. Cambridge University Press. ISBN-13: 978-0521427685.

Chandan Roy (Ed.). 2019. The Role of Intellectual Property Rights in Agriculture and Allied Sciences 1st Edition. Apple Academic Press and CRC Press. ISBN:13-978-1771886987.

Gowthami Kumari Usha. 2017. Textbook on Plant Genetic Resources Conservation Paperback. ISBN: 13- 978-9327250978.

Kamalesh Adhikari and Charles Lawson. 2020. Biodiversity, Genetic Resources and Intellectual Property Developments in Access and Benefit Sharing. Routledge. ISBN 9780367592172.

NEMA. 2016. National Biodiversity Strategy and Action Plan II (2015-2025).

4.1.9 COURSE NAME: DESIGNING A SUSTAINABLE AND SUCCESSFUL PLANT BREEDING PROGRAMME

COURSE CODE: MPB 7202

COURSE OVERVIEW

Developing a successful plant breeding requires technical breeding expertise where one integrates knowledge of genetics (Mendelian, quantitative, genomics), biometrics, mathematics, physiology, pathology, entomology, soil science, experimental and crossing designs. This helps to realistically estimate heritability, genetic variation, gene action, and G×E interaction and hence the breeding value of the program. In addition, today's plant breeder must also possess legal knowledge, business skills, team building skills, intellectual property law, biosafety regulations, financial management, good understanding of the stakeholder factors that affect the adoption of new varieties. Thus, developing a viable program requires integration of knowledge acquired during the program study.

COURSE OBJECTIVES

i) To plan, develop and assess specific breeding programmes for different environments, considering the available materials and stakeholder needs, the set objectives and the agronomic, environmental and socioeconomic constraints.

LEARNING OUT COMES

i) Ability to develop and integrate the different components of a breeding programme and to plan its implementation, critically assessing the various conventional and molecular alternatives available.

ii) Understand the structure and logic of plant breeding programme and to plan a breeding programme for any given crop.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Introduction	Importance of plant breeding. Current status of plant breeding. Current challenges that hamper the development of plant breeding. Possible solution that can help to accelerate the breeding efficiency.	2

2	Main stages of plant breeding program	Setting priorities and Breeding objectives, generating variation, selection, testing and final selection, release of varieties and seed multiplication	2
3	Defining the breeding product	Breeding traits. Quality of varieties. Re-thinking the prioritization of plant traits for commercial suitability.	2
4	Breeding materials and other resources	Sources of plant breeding materials. Linkage between biodiversity and crop improvement	2
5	Modes of breeding	Conventional vs high throughput breeding methods (opportunities/advantages and challenges/disadvantages)	2
6	Capacity building	Human resources and other resources. Resource mobilisation	2
7	Formal registration and certification system	Phase1: Breeding process, including VCU/DUS tests; Registration/ Release of varieties; Quality-controlled multiplication in certified seed plots. Phase2: Testing of samples; seed certification; seed storage and Packaging; seed distribution and marketing of breeding products	4
8	Increasing and measuring plant breeding efficiency	Increasing the response to selection: Reduce breeding cycle (single seed descent, double haploid, MAS); increasing heritability (more replications, decentralized selection, selecting for specific adaptation). Increasing adoption rates (involving stakeholders in identifying breeding priorities). Evaluating breeding program using benefit/cost ratio, net present value and internal rate of returns.	6
9	Optimisation of plant breeding programs	Use of computer simulations to predict genetic gain (AlphaSimR, Selection index tool, multi-environment trial (MET) analysis tool, Optimal selection methods, Optimal program sizes, Choosing the right number of testers, implementing hybrid breeding, implementing genomic selection, Selecting the right number of environments, Effects of reduced cycle time (EiB), Breeding scheme designer, Breeding Costing Tool,	4
10	GxE interaction analysis for	Comparison of GxEI analysis methods for selection decision making.	4

	effective selection of genotypes		
11	Embracing System-based breeding	Defining a systems-based breeding. Required change in attitude. From attitude to action. From action to achievement. The role of system-based plant breeding in ensuring sustainability. Breeding models adopted in system-based breeding (Community-based breeding. Ecosystem-based breeding. Trait-based breeding. Corporate-based breeding. The need to combine potentials of the four paradigmatic orientations).	5
12	Tutorial	Visiting institutions (NaCRRI, NARL, NaSARRI, NaFORRI) operating plant breeding programmes.	10
	Total		

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in inform of quizzes, tests, presentations, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

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4.1.10 COURSE NAME: SEED TECHNOLOGY AND VARIETY RELEASE

COURSE CODE: MPB 7203

CREDIT UNITS: 3

COURSE OVERVIEW

The course provides an overview of principles and best practices for quality seed production, processing, storage, marketing and legislation.

COURSE OBJECTIVES

i) To acquaint students with the principles of quality seed production and processing

ii) To expose students to seed supply systems, concepts and principles of effective marketing of seed and strengths and weaknesses of the seed sector

iii) To acquaint students with the legislative processes and the mechanisms of seed quality control

iv) To know about various aspects related to seed certification and seed legislation

v) To create awareness of unique challenges associated with seed production of specialty crops and transgenic cultivars

vi) To impart knowledge different aspects of seed physiology (physiological and biochemical basis of dormancy and seed germination)

vii) To provide students with the methodology of conducting and applying the industrial tests for monitoring seed quality

LEARNING OUTCOMES

i) The course will help students to understand the aspects of seed physiology, biochemical basis of dormancy and seed germination

ii) The knowledge in seed physiology acquired by the students will be useful for achieving higher crop stand

iii) Students will acquire skills in operating seed processing and testing equipment

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1.	Introduction	Definition seed. Importance of good quality seed. Features of good quality seed. Classes of seed and generation system of seed multiplication. Varietal maintenance and causes of varietal deterioration. Maintenance of genetic purity during seed production.	2
2	Seed physiology and testing	Seed development and maturation. Seed germination: phases of seed germination and types and causes of seed dormancy; how to overcome seed dormancy. Seed viability and germination tests.	2
3	Quality seed production for self and cross pollinated crops	Suitable areas of seed production and storage, agronomy of seed production. Agro-climatic requirements for seed production and their influence on quality seed production. Criteria involved in generation system of seed multiplication; production and maintenance of nucleus seed, breeder, foundation seed, certified seed and quality declared seed. Production of seed for GM crop, synthetic and composite varieties.	3
4	Hybrid seed production	Hybrid seed production systems. Development of A, B and R lines. Types of male sterility, chemical hybridizing agents (CHA) and use in hybrid seed production. Self-incompatibility, its genetics and use in hybrid seed production, causes for hybrid seed deterioration. Seed production, methods, processing and storing. Heterosis; inbreeding depression, genetic, physiological and biochemical basis of heterosis and its implication in hybrid seed production.	4
5	Postharvest	Threshing methods. Drying methods. Seed processing: seed cleaning	4

	handling and processing of seed	grading and packing. Seed processing equipment and how they are used. Seed quality enhancement techniques: importance, seed fortification, seed priming, seed coating, seed pelleting	
6	Seed quality control	Seed certification procedure and objectives of seed certification. Field inspection process, field and seed standards. Post-harvest inspection (processing, bagging and tagging). Testing seed quality, viability, vigour and health (importance of seed pathology).	4
7	Seed storage	Factors affecting seed longevity during storage. Seed treatments and packaging materials - measures for pest and disease control during storage and sanitation. Concepts and significance of moisture equilibrium, methods of maintaining safe seed relative humidity and equilibrium moisture content (MC). Methods to minimize the loss of seed vigour and viability. Preparing seed for processing; scalper debearder, scarifier, hullar, seed cleaner and grader, screen cleaner, specific gravity separators, indented cylinder separator, velvet separator, spiral separator, disc separator, colour sorter…	4
8	Seed marketing (Demand and supply)	Role of seed replacement rate (SRR), seed multiplication ratio (SMR), cost of production and returns; determining seed needs; seed pricing and price policy, seed processing and packaging, demand forecasting. structure and organization of seed marketing and sales promotional activities. Factors affecting seed marketing, strengths and challenges of the seed sector and role of various sectors/agencies (national and international) in efficient seed trade.	4
9	Seed regulation policies	Act and Rules-Seed law enforcement. Salient features of the National Seed Policy and Act. Duty and powers of seed inspector, offences and penalties. Seed testing for quality assessment: importance; varietal identification through grow-out test and finger printing.	2
10	Variety release processes	Definition of- variety, cultivar, extant variety, essentially derived variety, independently derived variety, reference variety, farmers‟ variety, hybrid, and population. General procedure of variety release procedure. Plant Variety Protection and its significance; UPOV and its	4

		role; DUS testing- principles and applications.	
11	Tutorial/practicals	Study of morphological characters of different crop seeds. Measurement of seed moisture content by direct and indirect methods drying methods. Seed sampling and seed tests (physical purity, germination, viability, seedling vigour test, genetic purity test, grow out test and electrophoresis. Visit to seed production processing companies to visualize the seed processing operations. Field inspection at various stages	12
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done inform of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

REFERENCES

Agarwal, P.K. 2010. Principles of Seed Technology. Indian Council of Agricultural Research. ISBN: 13-9788171640591.

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4.1.11 COURSE NAME: APPLIED AGRICULTURAL EXTENSION

COURSE CODE: MPB 7204

COURSE OVERVIEW

Applied agricultural extension is important in transformation of the agricultural sector. The course will therefore expose students to the role of extension science in agricultural production particularly highlighting the issues of agricultural technology transfer and advisory. The course will also deal with the definition and importance of extension and approaches and advances to agricultural technology transfer. In addition, various aspects that ensure proper extension service delivery will be tackled in relation to the latest trends in extension science indicating the significance of extension in agricultural production.

COURSE OBJECTIVES

i) To describe the process and steps involved in agricultural extension in the transfer of technology.

ii) To understand Agricultural Knowledge Information Systems (AKISs).

iii) To understand advances in extension and be able to select appropriate extension methods.

iv) To analyze the strength and weakness of various extension teaching methods/approaches

v) To orient the students regarding various concepts, tools, applications, approaches projects and issues of ICT in extension

LEARNING OUTCOMES

At the end of the course students should;

i) perceive the importance of applied agricultural extension methods with respect to technology transfer among the farming environments.

ii) know the different strategies and use of modern tools to disseminate and diffuse demand-driven technologies among the farmers' and provide realistic solutions to solve farmers' problems.

iii) know the ICT based technologies to successfully run any extension-based projects.

iv) know the role of international organizations involved in extension services.

v) plan for the extension service delivery and identify the needed services.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
	Introduction	Definition and importance of agricultural technology transfer. Extension teaching methods, their merits, demerits, and applicability. Evaluate the technology transfer process. Identify barriers to technology transfer.	5
	Approaches of Agricultural Extension in technology transfer	A critical analysis of different approaches of agricultural extension. Importance and relevance of indigenous knowledge system, Integration of ITK system in research formulation, Concept of Agricultural Knowledge and Information System (AKIS)	5
	Recent advances in agricultural extension methods	Cyber Extension. Concept of cyber extension, national and international cases of extension projects using ICT and their impact of agricultural extension.	4
	Research - Extension interface	Farmer - Market linkage: Importance, Scope, Implications etc., Market - Led Extension, Farmer - Led Extension, Concept of Farm Field Schools	5
	Public - Private Partnership:	Meaning, Models, Identification of various areas for partnership, Stakeholder's analysis in Extension, Main streaming gender in Extension - Issues and Prospects.	5
	Extension and contemporary issues	Extension and issues related to rural poverty, Privatization of Extension, Extension Reforms in Uganda - Decentralized decision making, bottom-up planning, Farming System and Situation based Extension Delivery System, Extension delivery through Commodity Interest Groups,	3
	Transfer of appropriate Technology	Meaning and concepts. Systems of transfer of technology (Knowledge Generating System (KGS), Knowledge	3

		Disseminating System (KDS), Knowledge Consuming System (KCS), Input Supplying Agencies System (ISAS). Critical analysis of alternative extension methods	
	Tutorials and study visits	Students will plan, analyze, and apply given extension teaching method(s) in the simulated situation. Analysis of ITK systems, cases on integration of ITK and formal research system, Analysis of cases on cyber extension and privatization of extension, Practicing bottom-up planning. Visit to Public-Private –Farmer partnership groups. Analyze strengths and weakness of the extension system in selected countries	10
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in inform of quizzes, tests, presentations, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

REFERENCES

Adereti, F.O. and A.O. Ajayi. 2005. Concepts and Basic Principles of Agricultural Extension. In: S.F. Adedoyin (ed).

Blum, M.L., F. Cofini, R.V. Sulaiman. 2020. Agricultural extension in transition worldwide: Policies and strategies for reform. FAO. https://doi.org/10.4060/ca8199en.

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Karthikeyan, C., R. Sendikumar and D. Jaganathan. 2007. A Textbook of Agricultural Extension Management. Atlantic Publishers & Distributors (P) Ltd.

Kristin, D., S.C. Babu and C. Ragasa (Eds.). 2020. Agricultural extension: Global status and performance in selected countries. Washington, DC: International Food Policy Research Institute (IFPRI). https://doi.org/10.2499/9780896293755

Volker Hoffmann, V., M. Gerster-Bentaya, A. Christinck and M. Lemma (Eds.). 2009. Handbook:

Santucci, M. 2005. Strategic Communication for Rural Development In collaboration with the Communication for Sustainable Development in Operations Unit Development Communication Division External Affairs.

Torimiro, D.O., O.A. Akinyemiju and O.J. Soyelu. 2020. Agricultural Extension Practices: A Subject Matter Approach. LAP LAMBERT Academic Publishing.

4.1.12 RECESS TERM (10 WEEKS)

Students will be hosted by organisations that have active plant breeding activities for 10 weeks. During their stay at the organisations they will participate is various breeding and crop production activities in order to gain hands-on experience.

4.1.13 YEAR TWO: SEMESTER ONE (17 WEEKS)

4.1.14 COURSE NAME: ADVANCED BIOMETRICS-2: MULTIVARIATE AND MULTIPLE REGRESSION ANALYSIS

COURSE CODE: MPB 7101

CREDIT UNITS: 3

COURSE OVERVIEW

The course provides students with a joint analysis of high dimensional data with multiple dependent variables which can be represented using vectors and matrices. The analysis leads to data reduction and searching for groupings (clusters) and classification. During the course multivariate analysis techniques are introduced and relationships between them examined using various software such as R, SAS, SPSS or Stata. Much emphasis is put on interpretation of results and practical application of information. The methods examined include multivariate extensions of t-tests and analysis of variance, regression and dimension reduction techniques

such as principal component analysis, factor analysis, canonical correlation analysis and clustering methods.

COURSE OBJECTIVES

i) To learn basic matrix algebra for statistical use and be able to use it to understand statistical methods.

ii) To learn how to visualize multivariate data using various statistical methods

iii) To learn how to determine which multivariate methods are appropriate for a particular situation

iv) To learn how to use software packages for data analysis.

LEARNING OUTCOMES

Upon course completion students should be able to:

i) identify the need for multivariate statistical techniques

ii) recognize the appropriate multivariate method for a problem

iii) employ statistical software to conduct appropriate data analysis

iv) interpret results and make statistical inference from research projects

v) judge if the assumptions for a multivariate statistical method are fulfilled

vi) estimate the parameters of a multivariate model using of statistical software

vii) interpret parameter estimates of a multivariate model

viii) absorb the content of s scientific publications about multivariate statistic

ix) present results of statistical analyses

x) have basic knowledge of the statistical program packages such as GENSTAT, SPSS, SAS, BMS, CIMMYT, Excel, STATA and LISREL

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 60 Contact Hours (CH) per semester; 30 lecture hours (4 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH

1	Introduction	Basic multivariate statistics–mean, variance, covariance, correlation, linear combination of variables	4
2	Matrix operations	Relevant vector and matrix algebra multivariate analysis of variance (MANOVA). General Method of Matrix Regression Analysis	3
3	Correlation and Regression	Bivariate Correlation and Regression. Data visualization, exploration, and assumptions. Multiple Regression/Correlation (partial relationships) Categorical or Nominal Independent Variables (dummy codding). Analysis of Covariance (ANCOVA)	4
4	Regression analysis	Methods used in regression analysis. Nonlinear regression, different methods for estimation (Least squares and Maximum likelihood). Generalised Linear Models (GLIM)	3
5	Logistic regression	Alternative Regression Models: Logistic, Poisson Regression. Analysis of binary and grouped data using logistic and log-linear models.	2
6	Model assumptions, multicollinearity, diagnostics	Data Visualization, Exploration, Missing Data and Assumption Checking. Outliers and Multicollinearity diagnosis. Model reduction methods	4
7	Multivariate normal distribution	maximum likelihood estimation, Wishart's distribution, Hotelling's T2 and hypothesis testing for multivariate normal data and rotation.	4
8	Data reduction methods	Principal components analysis (PCA): deriving principal components; PCA structural model; PCA on normal populations; biplots. Factor analysis: Factor analysis and the use of rotations; orthogonal factor and model estimation. Cluster analysis for grouping objects: Hierarchical clustering methods, measures of distance, non-hierarchical methods, model-based clustering. Discriminant analysis and allocation rules: Linear discriminant analysis; Fisher's method, discrimination with two groups; discrimination with several groups. Canonical analysis for highlighting differences between groups.	6
9	Analysis of	A review of standard analysis of variance (ANOVA). ANCOVA.	5

	Variance and generalizations	MANOVA (Multivariate ANOVA) and MANCOVA (Multivariate ANCOVA). Showing that ANOVA is special case of multiple linear regression analysis, with "dummy" independent variables, while ANCOVA is a special case of partial regression analysis.	
10	Tutorial	Chi-square and simple logistic regression. Model diagnostics. Data analysis using various software packages.	10
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done inform of tests, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

REFERENCES

Afifi A., S. May and V.A. Clark. 2012. Practical Multivariate Analysis. CRC Press.

Afifi, A., S. May, R. Donatello, V.A. Clark. 2021. Practical Multivariate Analysis 6th Ed. Chapman and Hall/CRC. ISBN 9781032088471.

Izenman A.J. 2013. Multivariate Regression. In: Modern Multivariate Statistical Techniques. Springer Texts in Statistics. Springer, New York, NY.

Keith, K.T. 2019. Multiple Regression and Beyond: An Introduction to Multiple Regression and Structural Equation Modeling 3rd Ed. Routledge. ISBN 9781138061446.

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4.1.15 COURSE NAME: SCIENTIFIC COMMUNICATION AND WRITING SKILLS

COURSE CODE: MPB 7102

CREDIT UNITS: 3

COURSE OVERVIEW

Graduate students will be trained in how to produce oral presentations and papers/posters for communicating scientific information. This will be achieved by enhancing knowledge and skills in scientific writing techniques and styles, effective oral communication, using electronic research tools and electronic presentation tools. The students will also attend a student-run seminar series and make presentations using electronic tools. They will also lead discussions about the role of scientific communication in society. During the semester, students will develop science communication projects springing from a scientific research topic of their choice in order to build competency. Projects can include articles for magazines intended for the general public, blogs, podcasts, videos or talks. Building knowledge and skills in generating and communicating scientific information will improve the general competence of the student in managing interdisciplinary scientific projects with diverse groups of individuals. The competence will improve the ability of students to organise and participate in research and development through established national and international research frameworks.

COURSE OBJECTIVES

i) To introduce to students the scientific communication methods and highlighting the role of communication in science

ii) To develop the students' practical communication skills through training in effective public speaking, writing skills and presentation skills

iii) To provide students with a range of resources and skills for effective scientific communication

iv) To provide students with the opportunity to undertake a substantial practical project in either scientific writing and science exhibition

v) To describe the stages of the scientific communication processes (prewriting, drafting, revising, final edits, analyzing audience and purpose)

vi) To learn how to use a combination of preparation and spontaneity to connect with audiences

vii) To be able to work competently and collaboratively with people of varied backgrounds and interests to expand scientific literacy

viii) To equip students with skills to write good thesis reports, research papers, etc.

ix) To equip the students with skills to effectively communicate and articulate in English (verbal as well as writing)

LEARNING OUTCOMES

When the course is completed students should know:

i) the common scientific communication methods;

ii) how to structure a scientific manuscript;

iii) how to identify parts of a scientific text that need improvement; structure and content of a good abstract and introduction;

iv) how to formulate a problem statement;

v) important principles for communicating research data;

vi) improve on own communication of research data.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1.	Introduction	Importance of good scientific writing	3
2.	Presentation skills	Various ways for effective scientific communication	3
3	Communication methods	1. Poster: Effective poster development using correl draw, power-point; defining an effective scientific research poster; characteristics of a good poster; tips for creating scientific good research posters; examples of good and bad posters; why a good poster is needed…… 2. Oral and impromptu presentation skills: defining oral and impromptu presentation; structure of oral presentation (introduction, main body and conclusion); Tips on designing a good oral presentation; steps in designing a good oral presentation; sequence in delivering oral presentation; tips on delivering oral presentation; tips	6

		on how to deal with difficult questions; body language; use of visuals; audience interaction and engagement	
4	Media for presenting research findings	Identify media for presenting research findings, highlight advantages and disadvantages of each medium	4
5	Writing publications	Reviewing scientific papers and writing scientific papers Ethical issues in publication	
6	Interpretation of Data and Paper Writing	Layout of a Research Paper, Journals in Crop Improvement and genetics, Impact factor of Journals and what it means, When and where to publish? Ethical issues related to publishing, Plagiarism and Self-Plagiarism.	4
7	Technical Writing	Various forms of scientific writings- theses, technical papers, reviews, Manuals … Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, citations, conclusions and recommendation, referencing, appendices, etc.; photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof reading of manuscripts;	8
8	Communication Skills	Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers	2
9	Tutorials	Seminar presentations of posters, proposal, use of visuals for effective communication	15
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous assessment of students before sitting the final examination. It is done in form of tests, assignments (a paper, an oral presentation, a poster) and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

REFERENCES

Alan Alda. 2017. If I Understood You, Would I Have This Look on My Face?: My Adventures in the Art and Science of Relating and Communicating. Random House Publisher. ASINB01M61KNLW.

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Jane Gregory and Steve Miller. 2000. Science in Public: Communication, Culture, and Credibility. Basic Books. ISBN: 13-9780738203577.

Laura Bowater and Kay Yeoman. 2012. Science Communication: A Practical Guide for Scientists. Wiley-Blackwell. ISBN: 978-1-119-99313-1.

Randy Olson. 2009. Don't Be Such a Scientist: Talking Substance in an Age of Style. Island Press. ISBN: 13-9781597265638.

4.1.16 COURSE NAME: CROP PHYSIOLOGY

COURSE CODE: MPB 7103

CREDIT UNITS: 3

COURSE OVERVIEW

The course provides studies about the role of physiology in commercial yield determination by looking at the crop morphology, physiological processes like respiration, transpiration, and photosynthesis, plant-water relations, stomata physiology, plant hormone functions, seed germination and dormancy, environmental stress and modeling for commercial yield under

various stress factors (biotic and abiotic). In addition, students receive hands-on training in the use of modern equipment used in crop physiology studies and several analytical techniques used in modern plant physiology in order to achieve optimum yield.

COURSE OBJECTIVES

i) To understand the canopy development process and its architecture, and its implications for efficient light harvest.

ii) To understand the mechanism of damage resistance and measurement of drought in crop plants

iii) To understand physiological basis of yield formation in crops

iv) To study various types of stresses in crop production and mitigation strategies

v) To equip the students with analytical techniques used in crop physiology

LEARNING OUTCOMES

By the end of the course students will:

i) know the importance of crop physiology

ii) know how to use the equipment and laboratory apparatus used for crop physiological studies

iii) know physiological process of germination and seed formation

iv) know the assimilation partitioning and translocation of metabolites in plants

v) know the role water in crop process (photosynthesis, phytohormones, nitrogen fixation, enzymatic activity and protein synthesis in plants)

vi) understand the process of stomatal movement and its role in adaptation against drought

vii) know the types and role of different growth regulators in plants

viii) be able to evaluate how different crops tolerate environmental stresses to produce economic yield

ix) devise strategies to improve crop production by integrating concepts, methods and models based on crop physiology

x) understand the influence of environment on growth and development of crops,

xi) be able to identify physiological indicators of maturity in crops.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
	Introduction	Role of crop physiology in agriculture. Impact of climatic extremities on growth and development of crops. Concept of potential yield and its realization in relation to agroecological zones of Uganda. Physiological and phenological attributes of tolerance in climate resilient crops.	2
	Crop productivity and modelling	Crop growth and productivity: crop growth models describing yield (Duncan/Passioura), phenology-crop productivity; growth factors related to biomass - concept of growth rates canopy photosynthesis (leaf area and net assimilation rates as determining factors). Crop response production functions. Crop production under protective agriculture. Solar radiation and available moisture regimes.	7
	Crop response to light stimulus and fate of assimilates	Light interception as a major function of leaf area index (LAI), LAD canopy architecture- Light extinction coefficient relative growth rate. Net assimilation rate. Biomass and yield relations. Assimilate partitioning, yield and yield structure analysis. Concept of source and sink: Factors influencing source and sink size and productivity. Environmental factors determining crop growth. Light, temperature and VPD, effect of photoperiod and thermoperiod on duration of growth stages. Ideotype concept-selection- indices for improving crop productivity.	
	Plant Growth Regulators and Plant Development	Plant growth regulators – Hormones, endogenous growth substances and synthetic chemicals. Endogenous growth regulating substances other than hormones. Brassinosteriods, triacontanol, phenols polyamines, jasmonates, concept of death hormone. Classification, site of synthesis, biosynthetic pathways and metabolism and influence on plant growth and development by auxins, gibberellins,	9

		cytokinins, abscisic acid and ethylene. Concept of hormone action - hormone receptors and signal transduction. Hormonal regulation of gene expressions at various developmental stages of plant growth (flowering, seed maturity, seed dormancy). Action of hormones on cellular functions (auxins, gibberellins, cytokinins, abscisic acid, ethylene). Hormonal concept of growth and differentiations. Apical dominance, senescence and abscission. Fruit growth and development: Induction and breaking dormancy in seeds and buds. Synthetic growth regulators: Practical utility in agriculture and horticulture.	
	Seed Physiology	Structure of seeds and their storage. Seed development patterns and source of assimilates for seed development. Pathway of movement of assimilates in developing grains of monocots and dicots. Chemical composition of seeds. Physiological processes. Mobilization of stored resource in seeds. Seed maturation phase and desiccation damage, role of LEA proteins. Seed viability. Seed dormancy. Means to overcome seed dormancy	5
	Abiotic Stress Responses in Plants	Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress. Drought characteristics, water potential in the soil-plant-air continuum. Stomatal functions/VPD. Physiological processes affected by drought. Drought resistance mechanisms: Escape, dehydration postponement, dehydration tolerance, and characteristics of resurrection in plants. Water use efficiency as a drought resistance trait. Stress and hormones (ABA and Cytokinin). Oxidative stress: reactive oxygen species (ROS) – role of scavenging systems (SOD, catalase etc.). High temperature stress: tolerance mechanisms- role of membrane lipids in high temperance tolerance. Functions of HSPs chilling stress and its effects on physiological processes. Salinity: salinity effects at cellular and whole plant level and tolerance mechanisms. Breeding for salt tolerance. Heavy metal stress: aluminum and	8

		cadmium toxicity in acid soils. Role of phyto-chelatins (heavy, metal binding proteins).	
	Post-Harvest Physiology	Senescence and ageing in plants. Ethylene effects. Monocarpic plant senescence. Gene expression during senescence. Concept of physiological maturity of seeds and environmental factors influencing post-harvest deterioration of seeds. Transgenic technology for improvement of shelf-life.	4
	Practicals/tutorials	Apply methods of measuring water availability and radiation use efficiency. Identification of growth stages of selected crops (cereals, legumes, oil crops, root crops). Identification of position, number and size of stomata. Centrifugation and use of tracers. Techniques used for studying water relations in plants. Plant growth analysis. Measurement of cell membrane permeability and stability. Demonstration of effect of magnetism on growth and development of plant. Measurement of leaf area and calculation of LAI. Calculation of indices of crop growth. Calculation of effective seed growth rate and duration. Calculation of partitioning coefficient.	10
	Tutorials/practicals		
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done inform of tests (20%), assignments (10%), practicals/tutorials and report writing (10%). It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

REFERENCES

Egli, D. 2021. Applied Crop Physiology: Understanding the Fundamentals of Grain Crop Management. CABI. ISBN: 9781789245950.

Gardner F.P. 2013. Physiology of Crop Plants. Springer-Verlag Inc., New York.

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Sadras, V.O. and D. Calderini. 2014. Crop Physiology: Applications for Genetic Improvement and Agronomy 2nd Ed. Academic Press. ISBN: 13-9780124171046.

Salisbury, F. B. and C. W. Ross. 2010. Plant Physiology. 5th Ed., Wordsworth Publishing Company.

Taiz, L. and E. Zeiger. 2010. Plant physiology. 6th Ed. Sinauer Associates, Inc., Publishers, Sunderland, USA.

4.1.17 COURSE NAME: AGRICULTURAL ENTOMOLOGY AND PLANT PARASITIC NEMATODES

COURSE CODE: MPB 7104

CREDIT UNITS: 3

COURSE OVERVIEW

The course provides overview of the economic importance of insect pests and plant parasitic nematode damage in agricultural cropping systems. It highlights how organisms become pests, insect and nematode damage and a brief description of control measures of insect pests and plant-parasitic nematodes to control population densities. Students will be able to relate basic insect and nematode morphological structures to ecology, life cycle, damage they cause and interactions with other organisms. Upon completion of the course students will appreciate the reasons why some insects become pests, and will be provided with intellectual tools to evaluate whether particular species might be causing economic damage. Students will be exposed to various pest sampling techniques and pest identification and pest damage analysis in relation to particular pests.

COURSE OBJECTIVES

i) To identify insects of economic importance and acquire working skills for collecting, mounting, and preserving insects.

ii) To study the roles of insects in agriculture

iii) To provide a foundation in pest management and economic decision making as applied to agro-ecosystems.

iv) To describe a range of methods to control insect pests, including their strengths, weaknesses and compatibility;

v) To identify and collect the pertinent information to make informed-management decisions on pest management.

vi) To familiarize the students with principles of insect pest management.

vii) To familiarize the students with types of damage caused by economically important pests.

LEARNING OUTCOMES

By the end of the course students will:

i) be able to identify insects of economic importance and acquire working skills for collecting, mounting, and preserving insects;

ii) appreciate the importance of insect and nematodes that affect the commercial value of crops,

iii) learn how to identify various economically important insect pests and nematodes basing on damage they cause and body parts.

iv) develop an understanding of the distributions and abundances of economically important insect pests and nematodes and making decisions on how they can be managed.

v) develop the ability to design and perform scientific studies about insects, analyze results and be able to make pest management decisions based on EIL estimation.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH

1.	Introduction	Definition of insect pests and economically (parasitic, entomopathogenic) and important plant nematodes and how organisms become pests. Nematodes as indicators of pollution and toxicity.	2
2.	Body structures of economically important insects and nematodes that cause crop damage	Body structures and modifications; types of mouth parts and modifications. Leg structures and modifications. Types of economically important insect life stages. Structure, modification and physiology of different systems (digestive, circulatory, respiratory, excretory, nervous, sensory, reproductive, musculature, endocrine and exocrine glands). Insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular microorganisms and their role in physiology; artificial diets.	3
3	Insect and nematode distribution	Study of abundance and distribution and relation between the two. Implications for abundance and distribution of insects and nematodes- Law of the Minimum, Law of Tolerance, and biocoenosis. Systems approach to ecology. Basic concepts of abundance- Model vs Real world. Population growth models: Exponential vs Logistic models. Discrete vs Continuous growth models. Balance of life in nature- Concepts of Carrying capacity, Environmental Resistance. Vital Statistics- Life Tables and their application to insect biology. Survivorship curves. Population dynamics- Factors affecting abundance: Environmental factors, dispersal and migration, Seasonality in economic insects and nematodes. Biotic factors- Food as a limiting factor for distribution and abundance. Food chain- web and ecological succession. Interspecific interactions- Basic factors governing the interspecific interactions- Classification of interspecific interactions Competition- Lotka-Volterra model, Concept of niche, ecological homologues, competitive exclusion. Prey-predator interactions- Defense mechanisms against predators/parasitoids-	5
4	Storage entomology	Types of insect pests and mites in storage. Sources and development of infestation. Detection of infestation. Fumigants and methods of	4

		fumigation. Seed protectants and their effect on seed viability.	
5	Causes of pest outbreak and resurgence	Pest resurgence and replacement (secondary pest outbreak). Causes and management of resurgence and replacement	2
6	Forecasting pest outbreaks	Forecasting pest outbreaks and surveillance (Short term and long-term forecasting); Forecasting based on observations – climatic and empirical factors	2
7	Types of damage caused by insect pest and nematodes	Injury by chewing, piercing, sucking insects, internal feeders, subterranean insects, to stored products and indirect effect of feeding	4
8	Decision making in management of insects and nematodes	Decision-making concepts: Economic thresholds; Action thresholds; Economic injury levels.	2
9	Ecological management and control of economically important insect pests and nematodes	History, definition and evolution, scope and need for IPM. Concept and philosophy, ecological principles. Tools of pest management and their integration legislative, cultural, physical and mechanical methods. History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control-importation, augmentation and conservation. Role of insect pathogenic fungi, bacteria, nematodes, viruses, protozoa etc., their mode of action. Biological control of weeds using insects. Mass production of quality biocontrol agents- techniques, formulations, economics, field release/application and evaluation. Examples of successful biological control projects, analysis, trends and future possibilities of biological control.	4

10	Chemical management and control of economically important insect pests and plant parasitic nematodes	Definition of insecticide toxicology; history of chemical control, Classification of insecticides based on mode of entry, mode of action and chemical nature. Mode of action of organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals etc. Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phytotoxicity. Insecticide metabolism; pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence. Insecticide residues, their significance and environmental implications. Safe use of insecticides; diagnosis and treatment of insecticide poisoning. Describe methods of insect control, Classes of insecticides, their formulation and application	7
11	Practicals and tutorials	Methods of sampling insects, estimation of densities of insect and understanding the distribution parameters- measures of central tendencies, poison distribution, negative binomial distribution. Calculation of some diversity indices- Shannon's, Simpson's index and understanding their association and the parameters that affect their values. Computation of life tables. Field visit, collection and identification of important pests and their natural enemies; detection and estimation of infestation and losses in different crops; study the life history of important insect pests. Collection, identification and mode of damage of insect pests of various crops, fruits, vegetables, stored grains and household; insecticide formulations, their dilutions and safe handling; use of application equipment. Methods of sampling for nematodes. Methods of killing, fixing, preserving, staining, mounting and measuring of nematodes. Experimental techniques for proving pathogenicity, estimation of crop losses, nematicide	10

		screening, screening and evaluation for nematode resistance in crops. Molecular technique for nematode diagnostics.	
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in inform of quizzes, tests, presentations, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

REFERENCES

David, B.V. and V.V. Ramamurthy. 2016. Elements of Economic Entomology, 8TH Ed. Brillion Publishing. ISBN: 13-978-0994869104.

Elzinga, R. 2004. Fundamentals of Entomology 6th Ed. Prentice Hall, Inc. ISBN 13: 9780130480309.

Mohamed Dayib Sheikh Abubakar. 2018. A Text-book of Economic Entomology Somali Natural Resource Research Centre (SONRREC).

Norman F. Johnson and A. Charles. 2005. Triplehorn Borror and DeLong's 2005 Introduction to the Study of Insects 7thEd. Brooks/Cole Publishing Co. ISBN13: 9780030968358.

William R. Nickle. 2020. Manual of Agricultural Nematology. CRC Press. ISBN 9780367402976.

5.1.18 SECOND YEAR SECOND SEMESTER COURSES

4.1.19 COURSE: PLANT PATHOLOGY

COURSE CODE: MPB 7201

CREDIT UNITS: 3

COURSE OVERVIEW

The course aims at providing knowledge about plant diseases and their management and sharpens the skills of students in various techniques and processes associated with plant protection. During the course, emphasis is put on enhancing analytical thinking ability which helps the students in handling and solving problems associated with plant diseases and their causal agents.

COURSE OBJECTIVES

To gain understanding on the importance of crop diseases caused by various agents.

To establish the infection and survival of plant pathogenic microbes

To be able to diagnose diseases causing agents basing on signs and symptoms

To get the information about how to manage and control plant disease by the use of various methods

To develop an insight into plant defense mechanisms against diseases.

LEARNING OUTCOMES

By the end of the course, the students will be able to: Discuss the importance of crop diseases and their causal agents. Describe the symptoms and types of plant diseases. Diagnose and identify common crop diseases and prescribe effective management options.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Introduction	History of Plant Pathology. Outline of classification of plant diseases	2
2	Plant Disease Epidemiology and Economic importance of plant pathogens and	Means of dissemination (active and passive dissemination) and ideal conditions for disease development. The roles that plant pathogens and diseases play in national and international trade, bio-security, and natural environments	2

	diseases		
3	Seed Pathology	Pathological Effects of Seed borne diseases- i) Seed abortion ii) Shrunken seeds and Reduced seed size iii) Seed rot iii) Sclerotisation & Stromatisation iv) Seed discolouration v) Reduced or complete loss of germinability	4
	Plant Disease Development	Molecular mechanisms of pathogenesis: Elicitors, recognition phenomenon, penetration, invasion, primary disease determinant. Enzymes and toxins in relation to plant disease. Mechanisms of resistance, Structural and Biochemical defense mechanisms. R-Genes, Phytoanticipins. Phytoalexins. PR proteins, Hydroxyproline rich glycoproteins (HRGP). Antiviral proteins. SAR and ISR. HR and active oxygen radicals. Management of pathogens through satellite, antisense - RNA. Ribozymes, coat protein, RNA interference, plantibodies, hypovirulence, cross protection.	
5	Plant defense mechanisms	Structural and biochemical; pathogenesis related proteins; Reactive Oxygen Species (ROS); Role of secondary metabolites; Elicitors and Receptors; Hypersensitive reactions; Defense strategies: role of oxidative burst, Phenolics, Pathogenesis Related (PR) proteins, Elicitors. Phytoalexins in plant defense; Mechanisms underlying systemic acquired resistance.	4
6	Genetics of plant disease resistance	'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance.	2
7	Pathogen identification	Microscopic techniques and staining methods, phase contrast system, chromatography, use of electron microscope, spectrophotometer, ultracentrifuge and electrophoretic apparatus, disease diagnostics, serological and molecular techniques for detection of plant pathogens. Evaluation of fungicides, bactericides etc.	4

8	Fungal aspects	Plant pathogenic fungi; ecology and spread of fungal diseases; host range; measurement of fungal growth; diseases caused by plant pathogenic fungi; pathogenicity and virulence factors of fungi; plant response to fungal infection; diagnosis of fungal diseases: symptoms, microscopic examination, isolation, confirmatory tests of fungi, pathogenicity. Fungi on seeds Characteristics of major storage fungi.	4
9	Aspects of Bacteria and Mollicutes	plant pathogenic bacteria; ecology and spread of bacterial diseases; host range; measurement of bacterial growth; diseases caused by plant pathogenic bacteria; pathogenicity and virulence factors in bacterial diseases; plant response to bacterial infection; diagnosis of bacterial diseases: symptoms, microscopic examination, isolation, gram stain test, biochemical tests, serological tests, fatty acid-based tests, Polymerase Chain Reaction (PCR)-based analysis	6
10	Viral and phytoplasma aspects	plant pathogenic viruses; ecology and spread of viral diseases; host range; diseases caused by plant pathogenic viruses; pathogenicity and virulence factors in viral diseases; plant response to viral infection; diagnosis of viral diseases: symptoms, Polymerase Chain Reaction (PCR)-based analysis, pathogenicity of viruses. Characteristics and ultra-structure of viruses/virions, isolation and purification of viruses, chemical nature, replication, transmission of viruses, economic importance of viruses. General characteristic and role of viruses in causing plant diseases.	4
	Principles of plant disease control	Attack on the parasite; strengthening of the host, modification of environments; biological control of plant pathogens; immune system (plant-microbe interaction); gene-for-gene interaction, acquired and systemic resistance (PR proteins); use of transgenics	
	Management of Plant diseases	General principles of plant quarantine. Exotic pathogens and pathogens introduced into Uganda. Sanitary and phytosanitary	

		issues under WTO, TRIPS and PRA. Microorganisms antagonistic to plant pathogens in soil, rhizosphere and phyllosphere and their use in the control of plant diseases; soil fungistasis. Plant growth promoting Rhizobacteria. Biotechnology for crop disease management	
11	Methods of plant disease control	Control through regulatory methods: Plant quarantine. Cultural and biological methods of control. Control through physical means. Chemical method for plant disease control: Fungicides, chemotherapy. Use of resistant varieties.	4
12	Practicals	Preparation and sterilization of common media. Methods of isolation of pathogens and their identification. Preservation of microorganisms in pure culture. Methods of inoculation. Measurement of plant disease. Isolation of soil fungi by Warcup method. Measurement of fungal growth by linear determination. Study of effect of incubation temperatures on fungal growth (150 C, 300 C & 600 C). Isolation of nematophagus fungi from garden soil/agriculture soil. Isolation of fungal pathogens from infected leaves. Study of different symptoms of plant diseases: i) Wilting ii) Leaf spot iii) Canker iv) Leaf mosaic. Inoculation and isolation of pathogens, purification of fungal culture, Koch's postulates. Methods of spore germination.	10
	Totals		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of quizzes, tests, presentations, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

REFERENCES

Balaji Aglave. 2018. Handbook of Plant Disease Identification and Management. CRC Press. ISBN 9781138585478.

David B. Collinge. 2016. Plant Pathogen Resistance Biotechnology. John Wiley & Sons, Inc. ISBN:9781118867761.

John A. Lucas. 2020. Plant Pathology and Plant Pathogens. Willey Blackwell. ISBN: 9781118893869.

Robert Burns (Ed.). 2008. Plant Pathology: Techniques and Protocols. Humana Press. ISBN: 9781588297990.

Tronsmo, A.M., D.B. Collinge, A. Djurle, L. Munk, J. Yuen and A. Tronsmo. 2020. Plant Pathology and Plant Diseases. CABI. ISBN: 9781789243185.

4.1.20 COURSE NAME: SOIL FERTILITY MANAGEMENT AND PLANT NUTRITION COURSE CODE: MPB 7202

COURSE OVERVIEW

The course provides students with a comprehensive understanding of the soil-nutrient-plant relationship with emphasis put on soil conditions affecting availability of plant nutrients. In this course a broad overview of the principles and applications of soil fertility management and plant nutrition shall be covered. The course covers topics on integrated soil fertility and nutrient management for sustainable agricultural production. The course assesses the importance various soil nutrients in plant metabolism and highlights deficiency symptoms and strategies for improving soil nutrient availability for plant use. It also covers different types of fertilizers, their production and application methods for improved soil and crop productivity.

COURSE OBJECTIVES

i) To impart knowledge about soil fertility evaluation, plant nutrients and the role of plant nutrients in plant growth and metabolism

ii) To equip students with knowledge on different types of fertilizers, their sources, production methods fertilizer calculations, and strategies for improving fertilizer and nutrient use efficiencies.

iii) To understand relationships between fertilizers, soils, and plant productivity and how these components dynamically interact to influence environmental quality and farmer profitability.

iv) To understand the implications of soil fertility management practices on agricultural sustainability and environmental protection.

v) To address multiple soil degradation challenges using integrated soil fertility and nutrient management strategies.

LEARNING OUTCOMES

By the end of the course students will;

i) know the crop nutrient requirements from organic and synthetic fertilizers and the different forms, types and application rates of fertilizers needed for economic plant growth.

ii) know modern methods in determining the content of nutrients in soil and soil quality for optimal use of fertilizers.

iii) be able to diagnose soil fertility and plant nutrition problems and develop appropriate recommendations to address such challenges.

iv) be able to design soil and nutrient management practices that maximize plant productivity and profitability.

DELIVERY MODE AND TIME ALLOCATED

This course has 3 Credit Units: 45 Contact Hours (CH) per semester; 30 lecture hours (2 contact hours per week for 15 study weeks) and 30 tutorial hours (1 contact hour per week for 15 study weeks).

S/N	Topic	Content	CH
1	Introduction	Definition of soil, importance of soil, and components of an ideal soil; Major soil types in Uganda and their characteristics	2
2	Soil fertility	Definition of soil fertility; Features of a fertile soil; Definition and causes of soil degradation; Soil fertility challenges to crop production in Uganda; Soil fertility management practices	6
3	Fertilizers	Definition, types (organic, foliar, biofertilizers and mineral fertilizers), advantages and disadvantages of different fertilizers;	7

		Grade analysis and determination of fertilizer application rates; Fertilizer use efficiency (FUE), FUE indices, and methods for improving fertilizer and nutrient use efficiency (the 4 Rs for effective fertilizer use); Composting-definition and types of composts; Methods of composting; Conventional composting, vermicomposting and entomo-composting; Factors influencing the composting process; Compost maturity and stability assessment.	
4	Integrated Soil Fertility Management	Definition of Integrated soil and nutrient management (ISFM); Historic approaches to soil fertility mgt in Africa; Principles of ISFM (use of mineral fertilizers, organic fertilizers, improved germplasm, combined fertilizer application, local adaptation, optimizing agronomic efficiency, sound agronomic principles, sound economic principles); The role of ISFM in agriculture. IFDC's Logical framework for implementing ISFM; Factors affecting the adoption of ISFM technologies	7
5	Plant nutrition	Definition of plant nutrition and plant nutrients. Classification of plant nutrients (macro, secondary, micronutrients and beneficial elements); Sources of plant nutrients; Pathways for soil nutrient loss.	3
3	Plant nutrients	Roles of nutrients (macro, secondary and micronutrients) in plant growth and metabolism; Nutrient deficiency symptoms; Nutrient toxicity; Soil pH and nutrient availability; Nutrient interactions and their effect on nutrient availability; Cation exchange capacity and availability of plant nutrients; Integrated nutrient management concepts	4
4.	Nutrient uptake process	Nutrient movement from soil to plants (Root interception, diffusion, and mass flow); Pathways for ion uptake in plants (Apoplastic, Symplastic and Vacuolar); Active vs passive transport; Factors influencing nutrient uptake by plants; Selective ion uptake and the carrier theory (affinity and capacity); Nutrient uptake, growth rate and nutrient content; Effects of stress on nutrient uptake (salinity, drought). optimization of plant population and planting geometry in	3

		relation to soil fertility	
5.	Diagnosis of nutrient problems	Methods of diagnosing nutrient problems: Yield gap analysis; Soil testing; Plant tissue analysis; Field observations; Diagnostic keys; Nutrient flow analysis; Resource flow mapping; Computer based diagnostic tools. Mitscherlich, Baule and Inverse- yield- nitrogen laws	3
12	Practicals	Procedure of plant and soil sampling for nutrient analysis; Determination of soil pH; CEC and organic carbon; Determination of total N and S, and available N and P in soil; Determination of macro, secondary and micronutrients in plant samples; Determination of exchangeable cations (K, Ca, Mg, Zn, Fe, Cu, B, Mn, Mo) in soil; Determination of gypsum requirement of alkali soils. Determination of soil pH, CEC, ECEC and liming requirements of acidic soils; Field diagnosis of plant nutrient deficiency and soil degradation; Preparation of organic fertilizers (compost and foliar) using different methods; Identification and field application of synthetic fertilizers; Preparation and interpretation of soil fertility evaluation reports.	10
	Total		**45**

MODE OF ASSESSMENT

Continuous Assessments: This evaluates the continuous performance of students before sitting the final examination. It is done in form of quizzes, tests, presentations, assignments and tutorials. It constitutes 40% of the final student's score.

University Examination: This covers 60% of the final score. It includes a written examination (essays, structured and multiple-choice questions).

REFERENCES

Deepak, G.P. and Yogeshvari K.J. (Eds.). 2019. Soil Fertility Management for Sustainable Development. Springer.

Marschner, P. 2012. Marschner's Mineral Nutrition of Higher Plants. 3rd Edition. Academic press (London, UK). ISBN: 987-0-12-384905-2.

Sanginga, N. and P.L. Woomer. 2009. Integrated Soil Fertility Management in Africa: Principles, Practices and Developmental Process. TSBFI-CIAT.

Scialabba, N. 2015. Training Manual for Organic Agriculture. FAO and TECA.

Verchot, L.V., F. Place, K.D. Shepherd and B. Jama. Science and Technological Innovations for Improving Soil Fertility and Management in Africa: A report for the NEPAD Science and Technology Forum.

Weil R. R. and Brady, N.C. 2016. The Nature and Properties of Soils. 15th Edition. Pearson. ISBN: 0133254488

Whalen, J (Ed.). 2012. Soil Fertility Improvement and Integrated Nutrient Management: A Global Perspective. Intech Open Book Series. eBook (PDF) ISBN: 978-953-51-4943-9.

4.1.21 COURSE NAME: MSc PLANT BREEDING THESIS

COURSE CODE: MPB 7203

CREDIT UNITS: 18

COURSE OVERVIEW

The thesis written from a personally conducted research is one of the requirements for the award of MSc Plant Breeding degree. It is a self-reflection whether the student has attained the learning outcomes of the programme by one's ability to prepare, execute and present a research project in both written and oral form under technical supervision. The research process leading to writing a thesis, will begin with developing a research proposal where the hypotheses are built from a personally felt problem or from reviewed literature. Components of the proposal will be: cover page, contents table, tables and figures, summary, chapter one (Introduction/Background, justification/problem statement, objectives, hypotheses), chapter two (Literature review), chapter three (methods and materials), work plan and budget, references, appendixes.

The thesis components will include; white matter (cover page, contents, table and figures, dedication, acknowledgement, abstract, chapter one (Introduction/Background, justification/problem statement, objectives, hypotheses), chapter two (Literature review), chapter three (methods and materials), chapter four (Results), chapter five (discussion), chapter six

recommendations and conclusion) work plan and budget, references, appendixes. However, the number of thesis chapters may differ depending on the number of objectives tackled in the study.

LEARNING OUTCOMES

After conducting the research study and writing the MSc Plant Breeding thesis students should be able to:

i) develop a research proposal based on existing or felt research problem

ii) formulate own learning objectives and process them into a research proposal

iii) conduct a literature search in relation to the topic of interest

iv) conduct research and convert the data collected into information

v) gain the skill of independent scientific and analytical thinking and know how to use scientific research methods to conduct research

vi) present a clear and understandable scientific report of the research conducted

MODE OF ASSESSMENT

Continuous assessment will be done and it shall constitute 40% of the final thesis mark where the graduate seminars will contribute 10%, proposal defense will contribute 10% and final proposal writeup 20%.

The final thesis will constitute 60% of the final thesis where the students shall make a 15-minute *viva voce* oral PowerPoint presentation which shall contribute 10% of the final thesis mark. In the presentation, students should show the relevance of their research, give a short introduction, discuss the applied methods and materials, the results, discussion, conclusions and recommendations and point out the research gap covered and what remains. The final thesis write up shall account for 50% of the final thesis.

APPENDIX 1: OUTLINE OF THE MSc THESIS REPORT

1) Title page: Title of the research project; Student name and registration number; supervisor(s) name(s); Date of submission

2) Table of contents, List of tables, List of figures, Acronyms

3) Declaration

4) Dedication and acknowledgement

5) Abstract/Executive summary

6) Introduction/background; scientific Justification or Problem statement; overall and specific objectives; hypotheses

7) Methods and Materials; study environment; study description indicating materials and approaches used; data analysis (type of data collected, methods of data processing and analysis)

8) Results

9) Discussion

10) conclusion and recommendations

11) References

12) Appendices (if available)

APPENDIX 2: MSc THESIS EVALUATION FORM

BUSITEMA UNIVERSITY
Pursuing Excellence

P.O.Box 236, Tororo
Gen:+256-454448842
Dir: +256-454448864
Mob: +256-782999874
Fax: +256-454436517
Email:ar@acadreg.busitema.ac.ug
Website:www.busitema.ac.ug

FACULTY OF AGRICULTURE AND ANIMAL SCIENCES

DEPARTMENT OF CROP PRODUCTION AND MANAGEMENT

MASTER OF SCIENCE IN PLANT BREEDING

MPB 7203: MSc THESIS EVALUATION FORM

STUDENT INFORMATION	
Name:	
Student number:	
Degree programme:	
Title of thesis:	
Date submitted:	
1ST EVALUATOR INFORMATION	
Name:	
Department:	
Institution of affiliation	
2ND EVALUATOR INFORMATION (not involved in supervising the student)	
Name:	
Department:	
Institution of affiliation	
Provisional grade:	
Final grade (average of 1st	

evaluator and 2nd evaluator scores):	
Date:	

EVALUATION OF THE CONTENT

The evaluator gives an assessment of each of the assessment areas in the table below by grading and giving a comment to support the mark awarded.

ASSESSMENT AREA	GRADE	COMMENTS
Background (10%)		
Justification/Problem statement (10%)		
Research methods and materials (20%)		
Results (15%)		
Discussion (10%)		
Conclusion and recommendations (10%)		
Overall presentation and final writeup (10%)		
Originality and contribution to existing knowledg bank (15%)		
Final grading A-Excellent (80%+) B-Very good (70%-79%) C-Good (60%-69%) D-fail (0-59%		

( ) PARENTHESES INDICATE MAXIMUM SCORE

APPENDIX 3: LIST OF ACADEMIC AND TECHNICAL STAFF

Sn	Name of Staff	Academic Qualifications	Specialty
1	Assoc. Prof. Dr. Masanza	BSc. Agric., MSc, PhD	Entomology
2	Dr. Geofrey Lubadde	BSc Agric. (Mak), MSc. CROP(Mak), PhD (UKZN)	Plant Breeding
3	Dr. John E. Wasige	BSc Agric.(Mak), MSc. (Mak), PhD (WU)	Soil science
4	Mr. Geoffrey Turyasingura	BSc.EDUC and VOC studies (KYU), MSC Agric. Extension (Mak)	Agricultural extension
5	Mr. Dennis Besigamukama	Bsc. Land Use, Msc, (PhD)	Soil science
6	Dr. Peter Opio	BSc (Agric), MSc, PhD	Post-harvest handling
7	Dr. Asha Nalunga	BSc (Agric), MSc, PhD	Agric. statistics
8	Dr. David Magumba	BSc (Agric), MSc, PhD	Agric. statistics
9	Dr. Ronald Kabbiri	BSc Agric. (SOK), MSc HORT(), PhD	Agric economics
10	Mr. Charles Andiku	Dip. Agroforestry, Bsc Hort.(MAK), Msc Crop Sci., (PhD Plant Breeding)	Plant breeding, Agronomy
11	Mr. Robert Amayo	Bsc Agric, Msc crop, (PhD)	Plant pathology
12	Mr. Andrew Musoba	Diploma in Crop Production &Mgt, BSc (Agric)	Dairy production and Production
13	Ms. Akol Susan	Diploma in Bee Production & Mgt, BAPM	Apiculture, Entomology
14	Mr. David Ojuu	DCP, Bsc Agric, Msc. (Crop Sci.)	Crop science
15	Mr. David Buluma	Diploma in Crop Production &Mgt, (BS Agric candidate)	Crop production & Management
16	Mr. Source Peter Oonyu	Diploma in Crop Production &Mgt, (BS Agric candidate)	Crop production & Management
17	Mr. Williams Muhindo	Certificate in General Agriculture, Diploma in Animal Production	Crop production & Management
18	Ms. Costa Gumisiriya	BSc. Agric., MSc. Crop Science	Crop science
19	Ms. Dorothy Alibo	BSc….. MSc….	Agronomy

20	Mr. Nicholas Munu	BSc….. MSc….	Farm power

BUDGET